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POISONOUS SNAKES OF THE UNITED STATES.

INTRODUCTION.

Snakes are easily confused with one another, and the question as to whether a certain one is poisonous or harmless arises again and again. Poisonous snakes are provided with a specific venomous fluid and an apparatus especially adapted for the introduction of this poison into their victims. As it is usual to regard all snakes as venomous, the burden of proof is upon those believing in their innocence. So many wonderful stories concerning snakes have been current from time to time that the public in turn becomes skeptical about everything concerning snakes or firmly believes in traditional accounts which usually are highly erroneous. Making allowance for misinterpretation of certain natural habits of reptiles, the grain of truth may be perceived in these traditions in spite of the exaggeration which ordinarily accompanies a good snake story.

The Elapidae, or Harlequin Snakes, occur from South Carolina and Arizona to South America (genus Micrurus), and are frequently confused with the nonvenomous Scarlet Snake (Cemophora coccinea) and the Scarlet Kingsnake (Lampropeltis elapsoides). The former differs from the Harlequin Snake (and also from the Scarlet Kingsnake, which it resembles very closely) in having the ventral surface yellowish white; the latter differs from the Harlequin in having the black cross bands less than half the width of the crimson.

The Crotalidae, or "Pit Vipers," occur throughout Temperate and Tropical America and include a number of venomous species which are familiarly known by the following names: Rattlesnakes (Crotalus spp.), the Massasauga (Sistrurus sp.), Cotton-mouth Water Moccasin (Agkistrodon piscivorus), and Copperhead (Agkistrodon mokasen). No true vipers are found on the American continents. The well-known Rattlesnakes, of which there are a number of species, are the most specialized of all the venomous snakes. The rattlesnake race has been extraordinarily adaptable, as its members have come to occupy the most diverse conditions of environment, including extremes of both humidity and aridity.

One of the Rattlesnakes is known as the Water Rattler (Crotalus adamanteus), because it is partial to the neighborhood of water and is said to be a good swimmer; yet others, the Pallid Rattler (Crotalus mitchelli), for example, live in typical deserts. The Prairie Rattler (Crotalus confluentus) occurs over the dryish areas of the Great Plains, while a related form, Crotalus horridus, is limited to the timbered areas of the eastern parts of the United States. It is certain that Rattlesnakes do not habitually climb trees, because they are poorly adapted to such an accomplishment, yet there is unquestionable proof that they do so occasionally. It requires little more agility to climb a rough-barked slanting tree than the face of a rocky ledge.

The Pigmy Rattler and the Massasauga (Sistrurus), are diminutive forms of true Rattlesnakes (Crotalus), attaining a length of nearly three feet and a thickness of less than one inch; their range is chiefly east of the Rocky Mountains, except for Arizona, and they are characteristically forms of the prairies and their swamps and marshes. The Cotton-mouth Water Moccasin frequents the low lands along southern rivers and the adjoining swamps into which the rivers overflow during high water; in its native haunts the Cotton-mouth is irritable and pugnacious, and when surprised throws its head back and opens its mouth disclosing the white lining. In the Northern States the Copperhead is partial to rocky places in the vicinity of timber, marshes, or abandoned stone quarries; in the South it frequents higher and drier ground than around the marshes; unless cornered, this snake usually attempts to escape unseen.

Key to the Poisonous Snakes of the United States.

Smaller snakes, characterized by brilliant colors; markings consisting of broad alternating rings of crimson and black, separated from each other by narrower yellow rings; black bands as broad as the crimson; a pair of short, erect perforated fangs in front of upper jaw.....Coral, or Harlequin, Snakes - ELAPIDAE

Head with yellow band across center and behind this a black ring; yellow body rings very narrow. South Carolina to Central America,
Harlequin Snake -Micrurus fulvius.

Head black over greater portion; yellow band on back of head and behind this a red ring; yellow body rings broader. Southern New Mexico, Arizona, and Northern Mexico.....Sonoran Coral Snake - Micrurus euryxanthus.

Larger snakes, characterized by duller colors; markings not forming regular alternating bands but consisting of blotches, diamonds, or incomplete bands; a pair of long fangs folding back against roof of mouth when jaws are closed; deep pit on face between nostril and eye; scales on upperparts keeled; pupils elliptical in shape, vertical in position....."Pit Vipers" - CROTALIDAE.

Tail without rattle, ending in a point..... Agkistrodon.

Color pattern distinct; ground color pale brown (grading into pale green on tail in Texas); blotches, or cross bands, reddish brown. Massachusetts to Florida, westward to Illinois and Texas, Copperhead, Highland Moccasin, or Chunkhead - Agkistrodon mokasen.

Color pattern obscure; ground color light to dark brown; cross bands darker, often indistinct and bordered with yellow spots; some of ventral scales on tail undivided. Virginia to Florida and Gulf States,
Cotton-mouth Water Moccasin - Agkistrodon piscivorus

Tail with rattle..... Sistrurus and Crotalus.

A single large scale on top of head between supraocular scales (those over eyes).....Sistrurus.

Size small; ground color grayish; large black blotches on back smaller series on sides. North Carolina to Florida, westward to Oklahoma, Arkansas, and Texas...Ground Rattler, or Pigmy Rattlesnake - Sistrurus miliarius.

Size medium; ground color brownish; large black blotches on back in close formation. Western New York to Ontario and Michigan, southward to northeastern Mexico, Massasauga - Sistrurus catenatus catenatus. and Sistrurus catenatus edwardsii.

Many small scales on top of head between supraocular scales (those over eyes).....Crotalus.

The genus Crotalus has 15 species in the United States, but the characteristics distinguishing these Rattlesnakes are too technical for presentation here. Their scientific and vernacular names and statements of their ranges follow:

Crotalus adamanteus - Diamond-back Rattler.
Southern South Carolina to Florida, westward to Louisiana, and Arkansas.
Crotalus atrox - Western Diamond-back Rattler.
Texas and Northern Mexico to Arizona, also Lower California.
Crotalus cerastes - Horned Rattlesnake, or Sidewinder.
Southern California, southern Nevada, Arizona, and southwestern Utah.
Crotalus confluentus - Prairie Rattler.
Great Plains from southern Canada to Texas.
Crotalus exsul - Red Rattlesnake.
Southwestern California and Lower California.
Crotalus horridus - Timber Rattler.
Maine to Georgia, westward to Great Plains.
Crotalus lepidus - Green Rattlesnake.
Border region of Texas, New Mexico, Arizona and adjacent Mexico.
Crotalus Mitchellii - Pallid, or Bleached, Rattler.
Arizona, Colorado Desert to southern Lower California.
Crotalus molossus - Dog-faced Rattler.
Southern Texas to southern Arizona, also northern Mexico.
Crotalus oregonus - Pacific Rattler.
British Columbia to southern California, western Idaho, and Nevada.
Crotalus pricei - Rattler.
Southern Arizona and adjacent region in Mexico.
Crotalus tigris - Tiger rattler.
Southern Arizona, southern Nevada, and southern Nevada.
Crotalus willardi - Rattler.
Santa Rita Mountain region Arizona, and northern Mexico.

POISON APPARATUS OF VENOMOUS SNAKES.

The fluid, or venom, is injected into the snake's victim by means of specialized teeth on the premaxillary bone of the upper jaw, which differ from normal reptilian teeth by having a groove, or canal, from base to apex. These venom fangs are large and readily observed. The canals of the fangs are fed with fluid from poison glands by means of excretory ducts which connect with the latter. Venom does not flow freely except when the snake is actually striking, for the end of the duct, which is not in contact with the base of the fang, is normally compressed by a sheath, or fold of the mucous membrane. A Rattlesnake may open its mouth to fullest extent and may or may not erect the fangs. The snake apparently has perfect control over its fangs, raising or depressing them at will. Introduction of venom is accomplished by the combined action of several muscles, which open the mouth, erect the fangs, and compress the poison glands, thus forcing the venomous fluid through the connecting duct into and through the fangs in the brief space of time in which the snake strikes its victim.

At the end of a stroke, the fangs of a poisonous snake are quickly withdrawn from the flesh for the whole action is the work of an instant. Unless the snake strikes again, the mouth closes as the fangs fold back, mechanical compression constricts the excretory duct, and pressure is relieved from the poison glands by relaxation of the enveloping muscles. A poisonous snake often miscalculates the distance of the object at which it is striking. In case the object is too close, the fangs are not fully erect when the snake strikes and hence do not penetrate. Conversely, if the thing struck at is beyond reach, the whole stroke may be completed without touching the object of attack. In this case it may happen that the venom is projected several feet, which has given rise to repeated accounts of spitting by poisonous snakes.

In human beings the bite of a venomous snake is usually followed by painful symptoms and occasionally by death. Other animals are affected in various ways. Among them the hog is reported to be immune from the bite of venomous snakes, possibly due to its thick skin and protecting layer of fat.

POISON FANGS.

Though the fangs of our venomous snakes are shed frequently it can not be said that they are shed periodically. On each side of the upper jaw there is a hollow or grooved poison fang firmly ankylosed to the premaxillary bone. This pair of functional fangs is supplemented by several pairs of smaller teeth growing loosely in the flesh and buried in the soft sheath of the gum. When from any cause one of the large fangs is broken off, the reserve fang nearest to it moves over in its place, grows fast to the premaxillary bone, and becomes the functional poison fang. In case of accident to either of the fangs in use there is always a reserve fang ready to replace it.

LENGTH OF STROKE.

The idea that a venomous snake can strike its full length of even a greater distance is another popular but erroneous belief. When a snake strikes from its usual S-shaped curved position, the anterior half of the body which

is thrown forward must be free from coil. In striking the snake simply straightens out the S-shaped curves. It does not have to be in this position to strike, for observation has shown that when irritated most of our poisonous snakes can strike from almost any position for short distances. The greatest length of stroke is about three-fourths the length of the snake.

VENOMS OF POISONOUS SNAKES.

Venom is a secretion of a gland which resembles in its development the parotid (a salivary) gland in mammals, and is composed of from 50 to 70 per cent of proteins; the chief remaining components are water and carbohydrates, with occasional admixtures of abraded epithelial cells, or saprophytic micro-organisms, while salts such as chlorides, phosphates of calcium, magnesium, and ammonium occur in small quantities. The reaction of venom to litmus is usually acid, in some cases neutral The venoms of the different species of poisonous snakes differ to a greater or lesser degree, though all venoms are multiple in nature, that is, they contain several toxins which act independently of each other. Warm-blooded animals are usually more susceptible to venom than cold-blooded. Dried venom retains its original toxic properties in unaltered strength and quality for an indefinite period. Dr. S. Weir Mitchell found that venom kept dry for 23 years was unaltered in these respects. In a fresh state the venom of a snake is a somewhat viscid fluid of a yellowish color. The specific gravity of the venom of our poisonous snakes, according to Mitchell, is as follows: Crotalus horridus, 1.054; C. atrox, 1.077; C. adamanteus, 1.061; Agkistrodon piscivorus, 1.032.

The effect of venom on the victim is due to the complicated action of several toxic elements, of which neurotoxins and hemorrhagins (explained below) are the most important. Neurotoxins have a destructive action upon the nervous system, and play the most important part in producing the death of a victim of venom poisoning. They are present in relatively large proportions, and are the chief death-dealing factors in the venom of the Harlequin Snake (Micrurus) one of the smaller poisonous snakes of the family Elapidae. Rattlesnakes (Crotalus and Sistrurus) and Moccasins (Agkistrodon) of the family Crotalidae produce neurotoxin in comparatively small quantities. The venom of the Cotton-mouth Water Moccasin contains more neurotoxin than that of the Rattlesnake, and consequently its paralytic effects on the respiratory center and motor nerves is stronger. This toxin not only breaks down the nuclei of the ganglion (nerve center) cells but produces granular disintegration of the sheath (myelin) and fragmentation of the conducting portions (axis cylinder) of the nerve fibers. These neurotoxins offer a high resistance to heat and retain their toxic properties after prolonged treatment with alcohol.

The hemorrhagins constitute the chief toxic constituents of Rattlesnake venom and have a solvent action on the endothelial cells composing the walls of the blood and lymph vessels, particularly the smallest of them known as capillaries. One of the most alarming symptoms ensuing from the bite of a "Pit Viper" is the enormous swelling and extravasation of blood around the wound. The blood escapes from the blood vessels through holes in the walls, for the walls of the vessels are really dissolved away in places. Red blood cells as well as white escape upon dissolution of the walls of the blood vessels.

The venoms of different species of snakes dissolve the red blood cells also in a similar fashion. This cell-dissolving substance which has a peculiarly destructive effect on red blood cells is called hemolysin. In dogs inoculated with venom the hemoglobin contained in the red blood cells readily crystalizes. It has been found in animals dying from suppression of urine after being bitten that the tubules of the kidneys are often completely blocked with hemoglobin crystals. The activities of the white blood cells (leucocytes) also are suspended by the action of the venom. Moreover, it has been found that venom contains elements which are agglutinating as well as dissolving for the white cells, and that these are distinct from those which affect the red blood cells.

Biochemical studies have shown that snake venom possesses four distinct classes of ferment-like substances apart from the cell dissolvers (cytolysins), and these are the fibrin ferment, and the proteolytic, diastatic, and lipolytic enzymes. One of the most remarkable features resulting from the bite of either the Rattlesnake or the Moccasin is the loss or the reduction of capacity of the blood for coagulation; it has been found that venom contains a powerful ferment which attacks the fibrin (the coagulating element) of the blood. The proteolytic enzyme of snake venom results in the softening of the muscles; the diastatic enzyme activates the inactive pancreatic juice, enabling it energetically to attack albuminoids; the fourth enzyme has a feeble lipolytic (fat dissolving) action in the splitting of lecithin and in fatty degeneration in the liver.

The quantity of venom yielded at one time by our venomous snakes increases, in general, in proportion to the size of the snake. The following table gives the dry weight of a single extractable dose from both glands, presumably about the same quantity ejected by the snakes at one attack:

Crotalus confluentus (Calmette)..... 0.105 gram dried.
Crotalus adamanteus (Flexner and Noguchi).... 0.179 to 0.309 gram dried.
Agkistrodon piscivorus (Flexner and Noguchi). 0.125 to 0.18 gram dried.
Agkistrodon mokasen (Flexner and Noguchi).... 0.03 to 0.06 gram dried.

Flexner and Noguchi found the solid portion of venom (Crotalus and Agkistrodon) to range from 50 to 70 per cent of the total weight. Since one avoirdupois ounce equals 28.35 grams, the maximum dose of venom, according to the foregoing table, would be less than 1/70 of an ounce.

Furthermore, Mitchell published the following observations on the quantity of venom yielded by four rattlesnakes:

Length, 18 inches; weight, 9 1/2 ounces; capacity of gland, 11 drops.
Length, 25 inches; weight, 18 ounces; capacity of gland, 19 drops.
Length, 49 1/2 inches; weight, 3 pounds 2 ounces; capacity of gland 29 drops.
Length, 8 1/2 feet; ejected 1 1/2 drams of venom at single bite.

Thus the actual amount of venom injected into a victim depends largely on the size of the snake, the length of time during which its supply has been accumulating, the depth to which the fang is thrust into the flesh, as well as on

the location of the bite. In the majority of cases human beings recover without any treatment, for the simple reason that the quantity of venom injected is not a fatal dose.

Mitchell repeatedly pointed out the danger of secondary bacterial infection in victims surviving the primary effects of snake poisoning and W. H. Welch, in 1895, discovered that rattlesnake venom causes blood to loose its bactericidal power. Normal blood serum destroys thousands of bacteria, while venomized serum does not possess this power.

Some knowledge of the action of crotaline venoms is of greatest importance to American physicians, since 99 per cent of the cases of snake bite treated in the United States are caused by "Pit Vipers."

MORTALITY RESULTING FROM SNAKE BITE.

The average mortality from bites of the American venomous snakes is a little more than 10 per cent, but due to infrequency of bites, fatalities are extremely rare. Death from the bite of the Rattlesnake is an event of so rare occurrence that press reports of it appear as first page paragraphs in nearly every State in the Union. One factor which accounts for the rarity of accidents of this nature in the United States is that our citizens do not habitually go around bare-legged. Another explanation for the scarcity of accidents is that Rattlers do not generally inhabit lands suitable for cultivation, and, therefore, much frequented by man. The tendency of a Rattlesnake to rattle whenever disturbed and to continue the rattling as long as the disturbing influence is present also explains why victims are not more numerous. The Timber Rattler has been known to keep up its rattle for half an hour with a few intermittent momentary pauses. The fact that the Water Moccasin lives in unfrequented swamps, and that the Harlequin Snake is of burrowing habits and has a mouth of small size, accounts for the infrequency of bites of these species.

In fatal cases, the time intervening between the bite and death varies in different species. Cases terminating fatally within a few minutes do occur, though fortunately are very rare. There is a record (Roberts) that a boy seven years of age was bitten by a Rattlesnake on the cheek below the eye and pitched forward dead before an eye witness could reach him. A little girl three years old who was bitten on the forehead by a large rattlesnake died within 10 minutes (Blackwood). An analysis of 50 fatal cases resulting from the bites of American venomous snakes showed that 8 persons died in less than one hour, 13 between one and six hours, 18 in from one to twenty-four hours, 4 died on the second day, 4 died between the third and seventh days, 1 at end of nine days, 1 at end of seventeen days, and 1 lived over a month. The duration of illness following snake bite is subject to the widest variation, though in the majority of cases recovery from the constitutional disturbances is complete in two or three days, and in many cases in a few hours. Cases in which illness is prolonged are septic in character and are rarely, if ever, due to the primary action of the venom. The most important complications of snake bite are produced by the absorption of putrefactive substances (sepsis) and by acute alcoholism, resulting from mistaken treatment.

The bites of Pigmy Rattlers and Massassaugas (Sistrurus), are practically never fatal to adults, except, possibly through septic combinations. These rattlers are our least poisonous snakes, for of 20 cases on record none ended fatally. Of 408 persons bitten by Rattlesnakes (Crotalus) 48 died; on the other hand of 8 persons bitten by the Harlequin Snake (Micrurus) 6 died. Of 97 people bitten by the Copperhead (Agkistrodon mokasen) 5 ended fatally, while 9 persons out of 55 bitten by the Cotton-mouth Water Moccasin (Agkistrodon piscivorus) died. When death results from the bite of the Harlequin Snake (Micrurus), it is usually between 18 and 24 hours after the bite. Symptoms of drowsiness and general depression appear within an hour or so, and if the victim survives three or four days the danger of death passes away.

It is known that bites on the head and trunk are more dangerous than elsewhere, and that the mortality rate for bites on the upper extremities is practically double that for the lower. The mortality in children under ten years of age bitten by our venomous snakes is at least double that of adults. Dr. P. Willson found on study of 740 cases of bites of all kinds of our poisonous snakes that the mortality was 78 cases or 10.5 per cent.

The total number of deaths each year resulting from the bites of our venomous snakes represents a very low mortality, and indicates that these snakes are not so dangerous a pest as has often been assumed. This does not mean that one should needlessly take chances of being bitten by a Rattlesnake, for the bite, when not fatal, is followed by exceedingly painful symptoms and often impairment of the part bitten. Young Rattlesnakes only five or six inches long are capable of injecting poisonous venom in quantities sufficient to require treatment.

SNAKES COMMITTING SUICIDE.

Rattlesnakes are susceptible to their own poison and may cause death by biting themselves. There is a possibility, however, that the fang in such cases may have punctured the spinal nerve or some vital organ, and that death, therefore is not invariably due to the poison. Snakes are not likely to bite themselves except when severely injured or infuriated and unable to wreak vengeance on their tormentor.

TREATMENT FOR BITES OF NORTH AMERICAN POISONOUS SNAKES.

There can be no doubt that the chief precaution to take in case of snake bite is to prevent systematic absorption of a fatal dose of venom from the amount contained in the tissues immediately surrounding the wound. To accomplish this action must be prompt. Place a ligature above the knee or elbow if the wound is below this joint, and above the wound if on the upper arm or leg. This will delay absorption of venom, but the ligature must be loosened for a short time every thirty minutes to prevent gangrenous mortification.

Another means of minimizing absorption of the venom is by local incision of the area immediately surrounding the puncture of each fang.

This cutting must be free in all directions, and especially so in the direction of the blood return to the heart. After the punctures have been opened and the blood has flowed freely, the wound should be carefully washed with a strong solution of potassium permanganate. Another method equally successful is to inject an aqueous solution of permanganate of potash with a hypodermic syringe into the puncture of each fang and then open the punctures with a knife as directed above. Permanganate of potash will neutralize about its own weight of venom and is effective against every class of snake venom. The leaves and stems of the vine Mikania guacho have been advocated as an antidote for the recurrent symptoms which are after effects of bite of the Harlequin Snake.

Local treatment is of greatest importance, and in addition the patient should be kept warm and as quiet as possible. Mechanical means also should be employed, such as bandaging, abdominal compression, and posture to keep up blood pressure and circulation in the vital centers.

The list of remedies which have been used in cases of snake bite, includes almost everything conceivable, from local applications of cloths saturated with urine to poultices made by splitting open living chickens. In the past, alcohol, in the forms of wine, whiskey, and brandy, has been freely administered, although there has been no foundation for its use except popular belief. Certain investigators demonstrated that the absorbed venom is eliminated in part by the stomach, and it was thought therefore that the venom could be precipitated by the alcohol before its reabsorption. Recent experiments have shown that alcohol precipitates venom but does not impair its toxic properties. By increasing the blood pressure, and in large doses intensifying coma, alcohol has a distinctly injurious influence on the victims of poisonous snakes.

The use of strychnine and caffein also should be avoided because of danger of increasing hemorrhage through the rise of blood pressure. In acute cases, when the venom has been injected directly into a blood vessel, the chances of recovery are slight. In such cases, and as a last resort, intravenous injections of strychnine may be employed to stimulate the nervous centers as speedily as possible. The injection of ammonia is useless and is often followed by serious complications.

Correspondence with firms manufacturing serums and allied preparations regarding the use of anti-venins indicates that these firms regard this treatment as impracticable in the United States and that such serums are not manufactured for general sale. The Rockefeller Institute for Medical Research has carried on experiments with anti-venins and in the past has prepared small quantities of serum for use in emergencies. To counteract or neutralize the poisonous effects of the bite of a venomous snake, it has been reported that it requires the intravenous injection of from 10 to 20 times as much antivenin as the quantity of venom injected by the snake. However, the fact that there are three types of poisonous snakes in the United States necessitating three distinct anti-venins, and that under the circumstances the calls

for any one kind are so infrequent, explains why biological manufacturing laboratories in the United States do not produce anti-venins. Thus our inquiries show that no anti-venin is being prepared in the United States which can be obtained immediately from wholesale or retail drug stores or from biological laboratories.

RATTLES.

According to popular superstition a Rattlesnake acquires a new ring on the rattle each year, and hence the number of rings composing the rattle was supposed to indicate the age of the reptile. This notion is wholly incorrect, for the Rattlesnake adds from two to four rings each year, usually three. Under normal conditions one ring is added each time the snake sheds its skin. The young Rattler is provided with a single button at birth, and within a few days it sheds its skin and commences feeding; in about two months it sheds its skin for the second time and then the first ring of the rattle is uncovered or added. This has been growing under the old skin, and its presence was apparent in the swollen appearance of the tail at the base of the original button. The last seven or eight vertebrae fuse together shortly after birth and form a composite bone known as the "shaker," and it is around this bone that each cap or ring of the rattle forms.

All of our snakes have the habit of shedding their skin one or more times during the year. The shed skin usually comes off entire, so that from head to tail it forms but a single piece of a very thin transparent material and is generally turned inside out. That part of the skin which covers the cap on the tail can not be shed on account of its peculiar shape. At the time the skin is shed, however, it is loosened and dislodged from its place and moves backward to become an additional ring on the rattle. Thus the rattle of the Rattlesnake is simply a series of shed caps or rings which are held together mechanically and loosely because of their shape. The rattle seldom numbers more than ten rings because the vibration at the tip is so great that the terminal rings are soon worn down or broken off.

It has often been asserted that nature equipped the Rattlesnake with this rattle to warn enemies away from its death-dealing fangs. A more reasonable explanation seems to be that the rattle is used as a call during the breeding season, and several naturalists have born witness to this interpretation. The idea that the Rattlesnake can not rattle when its rattles are wet from swimming, or being in wet grass or rain storms, is incorrect.

YOUNG.

In early fall the female Rattlesnake brings forth from six to nine young of about five inches in length, the eggs having been retained in the mother's body until hatched. The young display all the traits of the adults, and will try to rattle and bite as soon as they are born.

The Copperhead and the Water Moccasin are known to give birth to young during the month of July, and a litter averages from seven to nine.

Unlike the "Pit Vipers," the Harlequin Snake is oviparous and deposits its eggs late in May or early in June in decaying bark or damp soil. As many as seven eggs have been found together.

SNAKES SWALLOWING YOUNG.

It is a matter of popular belief that, in time of danger, the mother snake will swallow her young and allow them to emerge from her mouth after the danger is past. Several reliable witnesses have asserted that they have observed snakes to swallow young, and competent authorities have held that it would be possible for the young to live in the throat for a short period. So far as known, however, no one has gone on record with observations that the young have emerged again from the mother's mouth after they were swallowed.

DESTRUCTION OF SNAKES.

As their food consists of living prey, snakes can not be killed by poisoned baits. The only method thus far devised seems to be to kill them by clubbing or shooting. During the winter months most of our snakes are in a torpid condition. Late in the spring, however, and after the ground has become warmed up, Rattlesnakes and Copperheads make their appearance. In spring the colony for an entire neighborhood can be destroyed if the rocky ledge beneath which they have wintered or other hibernating retreat is located. Here in the early days of March and April they lie in the sun and are so sluggish that they may be easily dispatched with a club. Later on in the spring they spread out to the fields and the hillsides in search of mice, small birds, and other prey. Where conditions are favorable for the running of hogs these animals may be employed; this method has been reported by a number of observers as satisfactory in reducing the numbers of snakes. Water Moccasins are so abundant in the swamp lands of our Southern and Gulf States that control measures are practically impossible. They are not so plentiful in the cultivated sections, and should be destroyed whenever encountered. Because of their burrowing habits, Harlequin Snakes are not often observed; they are apparently quite rare in most sections of the South and are most frequently met at the time sweet potatoes are dug. Poisonous snakes are not without their own enemies. The Blacksnake (Coluber constrictor) and the Common Kingsnake (Lampropeltis getulus) are able to kill Rattlesnakes, and also the latter are known to eat them. The stomachs of several related forms of Kingsnakes have been found to contain remains of poisonous snakes. It has been reported that skunks occasionally kill Rattlers.

FOOD HABITS.

Examination of all accessible accounts indicates that Rattlesnakes feed on any sort of smaller vertebrates which may come within their reach. The following items have been found upon examination of stomachs: Ground

squirrels, chipmunks, pocket gophers, young prairie dogs, kangaroo rats, deer mice, meadow mice, and cottontail rabbits; various small lizards such as Uta, Cnemidophorus, and Gerrhonotus, frogs and toads; and occasionally birds as large as quail.

The food habits of the Copperhead and Cotton-mouth Water Moccasin, judging from published accounts, are essentially like those of the Rattlesnake, except that more aquatic vertebrates are available for the Water Moccasin. The Harlequin Snake does most of its feeding at night, capturing young snakes and lizards, particularly skinks (Plestiodon).

BIBLIOGRAPHY

Cope, E. D., The crocodilians, lizards, and snakes of North America. Rept. U. S. Nat. Mus., for 1898, Washington, D. C., pp. 153-1294; 1900.

Ditmars, R. L., The reptile book. A comprehensive, popularised work on the structure and habits of turtles, tortoises, crocodilians, lizards and snakes which inhabit the United States and northern Mexico. Doubleday, Page & Co., New York. pp. xxxii-472, with 6 color pls. and more than 400 photos; 1907.

Feoktistow, A. E., Eine vorläusige Mittheilung über die Wirkung des Schlangengiftes auf den thierischen Organusmus. Mem. d.l'Acad. Imp. d. Sci. de St. Petersbourg, (7) vol. 36, no. 4, pp. 32; 1888.

Fitzsimons, F. W., The snakes of South Africa: their venoms and the treatment of snake bite. New ed, Longmanns, Green & Co., New York; 1912.

Garman, S., On the evolution of the rattlesnake. Proc. Boston Soc. Nat. Hist., vol. 24, pp. 170-182, pls. 1-2; 1889.

Mitchell, S. W., Researches upon the venom of the rattlesnake with an investigation of the anatomy and physiology of the organs concerned. Smithsonian Contrib. to Knowledge, Washington, D. C., vol. 12, pp. vii, 139; 1860.

Mitchell, S. W., and E. T. Reichert, Researches upon the venoms of poisonous serpents. Smithsonian Contrib. to Knowledge, vol. 26, pp. ix, 186, pl.; 1886.

Noguchi, H., Snake venoms, an investigation of venomous snakes with special reference to the phenomena of their venoms. Carnegie Inst. Washington, pp. xvii, 315, pls. 33, figs. 16; 1909.

Phisalix, M., Anatomie comparee de la tete et de l'appareil venimeux chez les serpents. Ann. Sci. Nat. (zool.), Paris (9), vol. 19, pp. 1-114, figs; 1914.

Stejneger, L., The poisonous snakes of North America. Rept. U. S. Nat. Mus., for 1893, Washington, D. C. pp. 337-487, pls. 1-19, figs 70; 1895.

Tomes, C. S., On the development and succession of the poison fangs of snakes. Philos. Trans., London, vol. 166, pt. 2, pp. 377-385; 1876.

Willson, P., Snake poisoning in the United States: a study based on an analysis of 740 cases. Archives Internal Medicine, Chicago, vol. 1, pp. 516-570; 1908.

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UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF BIOLOGICAL SURVEY

POISONOUS SNAKES OF THE UNITED STATES.

INTRODUCTION.

Snakes are easily confused with one another, and the question as to whether a certain one is poisonous or harmless arises again and again. Poisonous snakes are provided with a specific venomous fluid and an apparatus especially adapted for the introduction of this poison into their victims. As it is usual to regard all snakes as venomous, the burden of proof is upon those believing in their innocence. So many wonderful stories concerning snakes have been current from time to time that the public in turn becomes skeptical about everything concerning snakes or firmly believes in traditional accounts which usually are highly erroneous. Making allowance for misinterpretation of certain natural habits of reptiles, the grain of truth may be perceived in these traditions in spite of the exaggeration which ordinarily accompanies a good snake story.

The Elapidae, or Harlequin Snakes, occur from South Carolina and Arizona to South America (genus Micrurus), and are frequently confused with the nonvenomous Scarlet Snake (Cemophora coccinea) and the Scarlet Kingsnake (Lampropeltis elapsoides). The former differs from the Harlequin Snake (and also from the Scarlet Kingsnake, which it resembles very closely) in having the ventral surface yellowish white; the latter differs from the Harlequin in having the black cross bands less than half the width of the crimson.

The Crotalidae, or "Pit Vipers," occur throughout Temperate and Tropical America and include a number of venomous species which are familiarly known by the following names: Rattlesnakes (Crotalus spp.), the Massasauga (Sistrurus sp.), Cotton-mouth Water Moccasin (Agkistrodon piscivorus), and Copperhead (Agkistrodon mokasen). No true vipers are found on the American continents. The well-known Rattlesnakes, of which there are a number of species, are the most specialized of all the venomous snakes. The rattlesnake race has been extraordinarily adaptable, as its members have come to occupy the most diverse conditions of environment, including extremes of both humidity and aridity.

One of the Rattlesnakes is known as the Water Rattler (Crotalus adamanteus), because it is partial to the neighborhood of water and is said to be a good swimmer; yet others, the Pallid Rattler (Crotalus mitchelli), for example, live in typical deserts. The Prairie Rattler (Crotalus confluentus) occurs over the dryish areas of the Great Plains, while a related form, Crotalus horridus, is limited to the timbered areas of the eastern parts of the United States. It is certain that Rattlesnakes do not habitually climb trees, because they are poorly adapted to such an accomplishment, yet there is unquestionable proof that they do so occasionally. It requires little more agility to climb a rough-barked slanting tree than the face of a rocky ledge.

The Pigmy Rattler and the Massasauga (Sistrurus), are diminutive forms of true Rattlesnakes (Crotalus), attaining a length of nearly three feet and a thickness of less than one inch; their range is chiefly east of the Rocky Mountains, except for Arizona, and they are characteristically forms of the prairies and their swamps and marshes. The Cotton-mouth Water Moccasin frequents the low lands along southern rivers and the adjoining swamps into which the rivers overflow during high water; in its native haunts the Cotton-mouth is irritable and pugnacious, and when surprised throws its head back and opens its mouth disclosing the white lining. In the Northern States the Copperhead is partial to rocky places in the vicinity of timber, marshes, or abandoned stone quarries; in the South it frequents higher and drier ground than around the marshes; unless cornered, this snake usually attempts to escape unseen.

Key to the Poisonous Snakes of the United States.

Smaller snakes, characterized by brilliant colors; markings consisting of broad alternating rings of crimson and black, separated from each other by narrower yellow rings; black bands as broad as the crimson; a pair of short, erect perforated fangs in front of upper jaw.....Coral, or Harlequin, Snakes - ELAPIDAE

Head with yellow band across center and behind this a black ring; yellow body rings very narrow. South Carolina to Central America,
Harlequin Snake -Micrurus fulvius.

Head black over greater portion; yellow band on back of head and behind this a red ring; yellow body rings broader. Southern New Mexico, Arizona, and Northern Mexico.....Sonoran Coral Snake - Micrurus euryxanthus.

Larger snakes, characterized by duller colors; markings not forming regular alternating bands but consisting of blotches, diamonds, or incomplete bands; a pair of long fangs folding back against roof of mouth when jaws are closed; deep pit on face between nostril and eye; scales on upperparts keeled; pupils elliptical in shape, vertical in position....."Pit Vipers" - CROTALIDAE.

Tail without rattle, ending in a point..... Agkistrodon.

Color pattern distinct; ground color pale brown (grading into pale green on tail in Texas); blotches, or cross bands, reddish brown. Massachusetts to Florida, westward to Illinois and Texas, Copperhead, Highland Moccasin, or Chunkhead - Agkistrodon mokasen.

Color pattern obscure; ground color light to dark brown; cross bands darker, often indistinct and bordered with yellow spots; some of ventral scales on tail undivided. Virginia to Florida and Gulf States,
Cotton-mouth Water Moccasin - Agkistrodon piscivorus

Tail with rattle..... Sistrurus and Crotalus.

A single large scale on top of head between supraocular scales (those over eyes).....Sistrurus.

Size small; ground color grayish; large black blotches on back smaller series on sides. North Carolina to Florida, westward to Oklahoma, Arkansas, and Texas...Ground Rattler, or Pigmy Rattlesnake - Sistrurus miliarius.

Size medium; ground color brownish; large black blotches on back in close formation. Western New York to Ontario and Michigan, southward to northeastern Mexico, Massasauga - Sistrurus catenatus catenatus. and Sistrurus catenatus edwardsii.

Many small scales on top of head between supraocular scales (those over eyes).....Crotalus.

The genus Crotalus has 13 species in the United States, but the characteristics distinguishing these Rattlesnakes are too technical for presentation here. Their scientific and vernacular names and statements of their ranges follow:

Crotalus adamanteus - Diamond-back Rattler.
Southern South Carolina to Florida, westward to Louisiana, and Arkansas.
Crotalus atrox - Western Diamond-back Rattler.
Texas and Northern Mexico to Arizona, also Lower California.
Crotalus cerastes - Horned Rattlesnake, or Sidewinder.
Southern California, southern Nevada, Arizona, and southwestern Utah.
Crotalus confluentus - Prairie Rattler.
Great Plains from southern Canada to Texas.
Crotalus exsul - Red Rattlesnake.
Southwestern California and Lower California.
Crotalus horridus - Timber Rattler.
Maine to Georgia, westward to Great Plains.
Crotalus lepidus - Green Rattlesnake.
Border region of Texas, New Mexico, Arizona and adjacent Mexico.
Crotalus mitchellii - Pallid, or Bleached, Rattler.
Arizona, Colorado Desert to southern Lower California.
Crotalus molossus - Dog-faced Rattler.
Southern Texas to southern Arizona, also northern Mexico.
Crotalus oregonus - Pacific Rattler.
British Columbia to southern California, western Idaho, and Nevada.
Crotalus pricei - Rattler.
Southern Arizona and adjacent region in Mexico.
Crotalus tigris - Tiger rattler.
Southern Arizona, southern Nevada, and southern Nevada.
Crotalus willardi - Rattler.
Santa Rita Mountain region Arizona, and northern Mexico.

POISON APPARATUS OF VENOMOUS SNAKES.

The fluid, or venom, is injected into the snake's victim by means of specialized teeth on the premaxillary bone of the upper jaw, which differ from normal reptilian teeth by having a groove, or canal, from base to apex. These venom fangs are large and readily observed. The canals of the fangs are fed with fluid from poison glands by means of excretory ducts which connect with the latter. Venom does not flow freely except when the snake is actually striking, for the end of the duct, which is not in contact with the base of the fang, is normally compressed by a sheath, or fold of the mucous membrane. A Rattlesnake may open its mouth to fullest extent and may or may not erect the fangs. The snake apparently has perfect control over its fangs, raising or depressing them at will. Introduction of venom is accomplished by the combined action of several muscles, which open the mouth, erect the fangs, and compress the poison glands, thus forcing the venomous fluid through the connecting duct into and through the fangs in the brief space of time in which the snake strikes its victim.

At the end of a stroke, the fangs of a poisonous snake are quickly withdrawn from the flesh for the whole action is the work of an instant. Unless the snake strikes again, the mouth closes as the fangs fold back, mechanical compression constricts the excretory duct, and pressure is relieved from the poison glands by relaxation of the enveloping muscles. A poisonous snake often miscalculates the distance of the object at which it is striking. In case the object is too close, the fangs are not fully erect when the snake strikes and hence do not penetrate. Conversely, if the thing struck at is beyond reach, the whole stroke may be completed without touching the object of attack. In this case it may happen that the venom is projected several feet, which has given rise to repeated accounts of spitting by poisonous snakes.

In human beings the bite of a venomous snake is usually followed by painful symptoms and occasionally by death. Other animals are affected in various ways. Among them the hog is reported to be immune from the bite of venomous snakes, possibly due to its thick skin and protecting layer of fat.

POISON FANGS.

Though the fangs of our venomous snakes are shed frequently it can not be said that they are shed periodically. On each side of the upper jaw there is a hollow or grooved poison fang firmly ankylosed to the premaxillary bone. This pair of functional fangs is supplemented by several pairs of smaller teeth growing loosely in the flesh and buried in the soft sheath of the gum. When from any cause one of the large fangs is broken off, the reserve fang nearest to it moves over in its place, grows fast to the premaxillary bone, and becomes the functional poison fang. In case of accident to either of the fangs in use there is always a reserve fang ready to replace it.

LENGTH OF STROKE.

The idea that a venomous snake can strike its full length of even a greater distance is another popular but erroneous belief. When a snake strikes from its usual S-shaped curved position, the anterior half of the body which

is thrown forward must be free from coil. In striking the snake simply straightens out the S-shaped curves. It does not have to be in this position to strike, for observation has shown that when irritated most of our poisonous snakes can strike from almost any position for short distances. The greatest length of stroke is about three-fourths the length of the snake.

VENOMS OF POISONOUS SNAKES.

Venom is a secretion of a gland which resembles in its development the parotid (a salivary) gland in mammals, and is composed of from 50 to 70 per cent of proteins; the chief remaining components are water and carbohydrates, with occasional admixtures of abraded epithelial cells, or saprophytic micro-organisms, while salts such as chlorides, phosphates of calcium, magnesium, and ammonium occur in small quantities. The reaction of venom to litmus is usually acid, in some cases neutral. The venoms of the different species of poisonous snakes differ to a greater or lesser degree, though all venoms are multiple in nature, that is, they contain several toxins which act independently of each other. Warm-blooded animals are usually more susceptible to venom than cold-blooded. Dried venom retains its original toxic properties in unaltered strength and quality for an indefinite period. Dr. S. Weir Mitchell found that venom kept dry for 23 years was unaltered in these respects. In a fresh state the venom of a snake is a somewhat viscid fluid of a yellowish color. The specific gravity of the venom of our poisonous snakes, according to Mitchell, is as follows: Crotalus horridus, 1.054; C. atrox, 1.077; C. adamanteus, 1.061; Agkistrodon piscivorus, 1.032.

The effect of venom on the victim is due to the complicated action of several toxic elements, of which neurotoxins and hemorrhagins (explained below) are the most important. Neurotoxins have a destructive action upon the nervous system, and play the most important part in producing the death of a victim of venom poisoning. They are present in relatively large proportions, and are the chief death-dealing factors in the venom of the Harlequin Snake (Micrurus) one of the smaller poisonous snakes of the family Elapidae. Rattlesnakes (Crotalus and Sistrurus) and Moccasins (Agkistrodon) of the family Crotalidae produce neurotoxin in comparatively small quantities. The venom of the Cotton-mouth Water Moccasin contains more neurotoxin than that of the Rattlesnake, and consequently its paralytic effects on the respiratory center and motor nerves is tstronger. This toxin not only breaks down the nuclei of the ganglion (nerve center) cells but produces granular disintegration of the sheath (myelin) and fragmentation of the conducting portions (axis cylinder) of the nerve fibers. These neurotixins offer a high resistance to heat and retain their toxic properties after prolonged treatment with alcohol.

The hemorrhagins constitute the chief toxic constituents of Rattlesnake venom and have a solvent action on the endothelial cells composing the walls of the blood and lymph vessels, particularly the smallest of them known as capillaries. One of the most alarming symptoms ensuing from the bite of a "Pit Viper" is the enormous swelling and extravasation of blood around the wound. The blood escapes from the blood vessels through holes in the walls, for the walls of the vessels are really dissolved away in places. Red blood cells as well as white escape upon dissolution of the walls of the blood vessels.

The venoms of different species of snakes dissolve the red blood cells also in a similar fashion. This cell-dissolving substance which has a peculiarly destructive effect on red blood cells is called hemolysin. In dogs inoculated with venom the hemoglobin contained in the red blood cells readily crystalizes. It has been found in animals dying from suppression of urine after being bitten that the tubules of the kidneys are often completely blocked with hemoglobin crystals. The activities of the white blood cells (leudodytes) also are suspended by the action of the venom. Moreover, it has been found that venom contains elements which are agglutinating as well as dissolving for the white cells, and that these are distinct from those which affect the red blood cells.

Biochemical studies have shown that snake venom possesses four distinct classes of ferment-like substances apart from the cell dissolvers (cytolysins), and these are the fibrin ferment, and the proteolytic, diastatic, and lipolytic enzymes. One of the most remarkable features resulting from the bite of either the Rattlesnake or the Moccasin is the loss or the reduction of capacity of the blood for coagulation; it has been found that venom contains a powerful ferment which attacks the fibrin (the coagulating element) of the blood. The proteolytic enzyme of snake venom results in the softening of the muscles; the diastatic enzyme activates the inactive pancreatic juice, enabling it energetically to attack albuminoids; the fourth enzyme has a feeble lipolytic (fat dissolving) action in the splitting of lecithin and in fatty degeneration in the liver.

The quantity of venom yielded at one time by our venomous snakes increases, in general, in proportion to the size of the snake. The following table gives the dry weight of a single extractable dose from both glands, presumably about the same quantity ejected by the snakes at one attack:

Crotalus confluentus (Calmette)..... 0.105 gram dried.
Crotalus adamanteus (Flexner and Noguchi)..... 0.179 to 0.309 gram dried.
Agkistrodon piscivorus (Flexner and Noguchi)..0.125 to 0.18 gram dried.
Agkistrodon mokasen (Flexner and Noguchi)..... 0.03 to 0.06 gram dried.

Flexner and Noguchi found the solid portion of venom (Crotalus and Agkistrodon) to range from 50 to 70 per cent of the total weight. Since one avoirdupois ounce equals 28.35 grams, the maximum dose of venom, according to the foregoing table, would be less than 1/70 of an ounce.

Furthermore, Mitchell published the following observations on the quantity of venom yielded by four rattlesnakes:

Length, 18 inches: weight, 9 1/2 ounces; capacity of gland, 11 drops.
Length, 25 inches; weight, 18 ounces; capacity of gland, 19 drops.
Length, 49 1/2 inches; weight, 3 pounds 2 ounces; capacity of gland 29 drops.
Length, 8 1/2 feet; ejected 1 1/2 drams of venom at single bite.

Thus the actual amount of venom injected into a victim depends largely on the size of the snake, the length of time during which its supply has been accumulating, the depth to which the fang is thrust into the flesh, as well as on

the location of the bite. In the majority of cases human beings recover without any treatment, for the simple reason that the quantity of venom injected is not a fatal dose.

Mitchell repeatedly pointed out the danger of secondary bacterial infection in victims surviving the primary effects of snake poisoning and W. H. Welch, in 1895, discovered that rattlesnake venom causes blood to loose its bactericidal power. Normal blood serum destroys thousands of bacteria, while venomized serum does not possess this power.

Some knowledge of the action of crotaline venoms is of greatest importance to American physicians, since 99 per cent of the cases of snake bite treated in the United States are caused by "Pit Vipers."

MORTALITY RESULTING FROM SNAKE BITE.

The average mortality from bites of the American venomous snakes is a little more than 10 per cent, but due to infrequency of bites, fatalities are extremely rare. Death from the bite of the Rattlesnake is an event of so rare occurrence that press reports of it appear as first page paragraphs in nearly every State in the Union. One factor which accounts for the rarity of accidents of this nature in the United States is that our citizens do not habitually go around bare-legged. Another explanation for the scarcity of accidents is that Rattlers do not generally inhabit lands suitable for cultivation, and, therefore, much frequented by man. The tendency of a Rattlesnake to rattle whenever disturbed and to continue the rattling as long as the disturbing influence is present also explains why victims are not more numerous. The Timber Rattler has been known to keep up its rattle for half an hour with a few intermittent momentary pauses. The fact that the Water Moccasin lives in unfrequented swamps, and that the Harlequin Snake is of burrowing habits and has a mouth of small size, accounts for the infrequency of bites of these species.

In fatal cases, the time intervening between the bite and death varies in different species. Cases terminating fatally within a few minutes do occur, though fortunately are very rare. There is a record (Roberts) that a boy seven years of age was bitten by a Rattlesnake on the cheek below the eye and pitched forward dead before an eye witness could reach him. A little girl three years old who was bitten on the forehead by a large rattlesnake died within 10 minutes (Blackwood). An analysis of 50 fatal cases resulting from the bites of American venomous snakes showed that 8 persons died in less than one hour, 13 between one and six hours, 18 in from one to twenty-four hours, 4 died on the second day, 4 died between the third and seventh days, 1 at end of nine days, 1 at end of seventeen days, and 1 lived over a month. The duration of illness following snake bite is subject to the widest variation, though in the majority of cases recovery from the constitutional disturbances is complete in two or three days, and in many cases in a few hours. Cases in which illness is prolonged are septic in character and are rarely, if ever, due to the primary action of the venom. The most important complications of snake bite are produced by the absorption of putrefactive substances (sepsis) and by acute alcoholism, resulting from mistaken treatment.

The bites of Pigmy Rattlers and Massasaugas (Sistrurus), are practically never fatal to adults, except possibly through septic combinations. These rattlers are our least poisonous snakes, for of 20 cases on record none ended fatally. Of 408 persons bitten by Rattlesnakes (Crotalus) 48 died; on the other hand, of 8 persons bitten by the Harlequin Snake (Micrurus) 6 died. Of 97 cases of bites by the Copperhead (Agkistrodon mokasen) 5 ended fatally, while 9 persons out of 53 bitten by the Cotton-mouth Water Moccasin (Agkistrodon piscivorus) died. When death results from the bite of the Harlequin Snake (Micrurus), it is usually between 18 and 24 hours after the bite. Symptoms of drowsiness and general depression appear within an hour or so, but if the victim survives three or four days, the danger of death passes away.

It is known that bites on the head and trunk are more dangerous than elsewhere, and that the mortality rate for bites on the upper extremities is practically double that for the lower. The mortality in children under ten years of age bitten by our venomous snakes is at least double that of adults. Dr. P. Willson found on study of 740 cases of bites by poisonous snakes of all kinds that the mortality was 78 cases, or 10.5 per cent.

The total number of deaths each year resulting from the bites of our venomous snakes represents a very low mortality, and indicates that these snakes are not so dangerous a pest as has often been assumed. This does not mean that one should needlessly take chances of being bitten by a Rattlesnake, for the bite, when not fatal, is followed by exceedingly painful symptoms and often impairment of the part bitten. Young Rattlesnakes only five or six inches long are capable of injecting poisonous venom in quantities sufficient to require treatment.

SNAKES COMMITTING SUICIDE.

It has been stated that rattlesnakes are susceptible to their own poison and that death has ensued from the effects of their self-inflicted wounds. There is a possibility, however, that the fang in such cases may have punctured the spinal nerve or some vital organ, and that death, therefore, is not invariably due to the poison. Snakes are not likely to bite themselves except when severely injured or when infuriated and unable to wreak vengeance on the tormentor. C. Phisalix has made experiments on the natural immunity of snakes to their own poison.

TREATMENT FOR BITES OF NORTH AMERICAN POISONOUS SNAKES.

There can be no doubt that the chief precaution to take in case of snake bite is to prevent systemic absorption of a fatal dose of venom from the amount contained in the tissues immediately surrounding the wound. To accomplish this, action must be prompt. Place a ligature above the knee or arm or leg. This will delay absorption of venom, but the ligature must be loosened for a short time every thirty minutes to prevent gangrenous mortification.

Another means of minimizing absorption of the venom is by local incision of the area immediately surrounding the puncture made by each of the fangs.

This cutting must be free in all directions, and especially so in the direction of the blood return to the heart. After the punctures have been opened and the blood has flowed freely, the wound should be carefully washed with a strong solution of potassium permanganate. Another method equally successful is to inject an aqueous solution of permanganate of potash with a hypodermic syringe into the puncture of each fang and then open the punctures with a knife as directed above. Permanganate of potash will neutralize about its own weight of venom and is effective against every class of snake venom. The leaves and stems of the vine Mikania guacho have been advocated as an antidote for the recurrent symptoms which are after effects of bite of the Harlequin Snake.

INSERT to be substituted for the paragraph beginning at the bottom of page 9 and ending at the top of page 10, Bi-571, "Poisonous Snakes of the United States."

Previous correspondence with manufacturers of serums and allied preparations regarding the use of anti-venins indicated that these firms regarded this method of treatment as impracticable in the United States. The Rockefeller Institute for Medical Research carried on experiments with anti-venins and in the past prepared small quantities of serum for use in emergencies. It was generally held that an intravenous injection of from 10 to 20 times as much anti-venin as the quantity of venom injected by the snake was required to counteract or neutralize the poisonous effects of the bite of a venomous snake. The poisonous snakes of the United States were grouped roughly into three categories according to the type of venom they possessed, and it was believed that three distinct anti-venins would be required to provide treatment for cases occurring within the boundaries of the United States.

Recent research has shown that a polyvalent serum could be produced that would be effective for all types of crotaline snakes, or pit vipers, in the United States, but that persons bitten by coral snakes would have to resort to some other method of treatment. The United States Public Health Service advises that the firm of H. K. Mulford Co., Broad & Wallace Streets, Philadelphia, Pa., recently has been licensed for the production and sale of anti-venin, marketed under the name "Antivenin (Nearctic Crotalidae)". So far as known, this is the only concern whose agencies in the United States are marketing a serum effective against the bites of poisonous snakes.

factured for general sale. The Rockefeller Institute for Medical Research has carried on experiments with anti-venins and in the past has prepared small quantities of serum for use in emergencies. To counteract or neutralize the poisonous effects of the bite of a venomous snake, it has been reported that it requires the intravenous injection of from 10 to 20 times as much antivenin as the quantity of venom injected by the snake. However, the fact that there are three types of poisonous snakes in the United States necessitating three distinct anti-venins, and that under the circumstances the calls

for any one kind are so infrequent, explains why biological manufacturing laboratories in the United States do not produce antivenins. Thus our inquiries show that no antivenin is being prepared in the United States which can be obtained immediately from wholesale or retail drug stores or from biological laboratories.

In the city of Butantan, San Paulo, Brazil, there is a splendid laboratory known as the Institution of Serum Therapy, where specific serums are prepared for different types of poisonous snakes. The New York Zoological Society made certain arrangements with the Brazilian Government for a small emergency supply which could be kept on hand for the treatment of their own employees. These serums were prepared at Butantan from venom supplied by the New York Zoological Society. The serum prepared at Butantan is produced by the immunization of horses. The horses are inoculated by small injections of snake venom, which are gradually increased in strength until the animal is able to withstand the injection of pure venom in quantities which under ordinary conditions would prove absolutely fatal. Antitoxins that neutralize the effects of the venom are produced in the blood of the inoculated horse. The blood of the immunized horse is extracted by humane methods and this is put through a process which separates the serous or colorless portion from the remainder. This in turn is concentrated and sealed up in pointed glass vials. It is a very simple matter to break off the tip of this vial and insert the needle of the hypodermic syringe when the occasion arises. The serum is injected under the skin of the abdomen. If kept in moderate temperature and away from the light, a tube of serum prepared in this manner should remain efficacious for fully eight years.

An emergency kit is being sold in this country including a simple but effective lance attached to a container holding crystals of potassium permanganate. These crystals will counteract the action of all types of venom if used promptly.

RATTLES.

According to popular superstition a Rattlesnake acquires a new ring on the rattle each year, and hence the number of rings composing the rattle was supposed to indicate the age of the reptile. This notion is wholly incorrect, for the Rattlesnake adds from two to four rings each year, usually three. Under normal conditions one ring is added each time the snake sheds its skin. The young Rattler is provided with a single button at birth, and within a few days it sheds its skin and commences feeding; in about two months it sheds its skin for the second time and then the first ring of the rattle is uncovered or added. This has been growing under the old skin, and its presence was apparent in the swollen appearance of the tail at the base of the original button. The last seven or eight vertebrae fuse together shortly after birth and form a composite bone known as the "shaker," and it is around this bone that each cap or ring of the rattle forms.

All of our snakes have the habit of shedding their skin one or more times during the year. The shed skin usually comes off entire, so that from head to tail it forms but a single piece of a very thin transparent material

and is generally turned inside out. That part of the skin which covers the cap on the tail can not be shed on account of its peculiar shape. At the time the skin is shed, however, it is loosened and dislodged from its place and moves backward to become an additional ring on the rattle. Thus the rattle of the Rattlesnake is simply a series of shed caps or rings which are held together mechanically and loosely because of their shape. The rattle seldom numbers more than ten rings because the vibration at the tip is so great that the terminal rings are soon worn down or broken off.

It has often been asserted that nature equipped the Rattlesnake with this rattle to warn enemies away from its death-dealing fangs. A more reasonable explanation seems to be that the rattle is used as a call during the breeding season, and several naturalists have borne witness to this interpretation. Inasmuch as the range of the buffalo coincided in a general way with the distribution of the Rattlesnake, the rattling of the tail was at least of mutual advantage to both, even though the actual evolution of the rattle was in no way associated with the need of such an organ. The wide ranging herds of grazing buffalo certainly accounted for a large number of snakes in the course of a season, and any creature which happened to be in the path of a herd would have a better opportunity to escape from being trodden down if it possessed some warning device. The idea that the Rattlesnake can not rattle when its rattles are wet from swimming or being in wet grass or rain storms, is incorrect.

YOUNG.

In early fall the female Rattlesnake brings forth from six to nine young of about five inches in length, the eggs having been retained in her body until hatched. The young display all the traits of the adults, and will try to rattle and bite as soon as they are born.

The Copperhead and the Water Moccasin are known to give birth to young during the month of July, and a litter averages from seven to nine.

Unlike the "Pit Vipers," the Harlequin Snake is oviparous and deposits its eggs late in May or early in June in decaying bark or damp soil. As many as seven eggs have been found together.

SNAKES SWALLOWING YOUNG.

It is a matter of popular belief that, in time of danger, the female snake will swallow her young and allow them to emerge from her mouth after the danger is past. Several reliable witnesses have asserted that they have observed snakes swallowing young, and competent authorities have held that it would be possible for the young to live in the throat for a short period. Of these writers Baron Palisot de Beauvois has contributed the most carefully recorded observations on young rattlesnakes crawling down the throats of their parents for protection against enemies. So far as known, however, no one has gone on record with observations that the young have emerged again from the mouth after they were swallowed.

DESTRUCTION OF SNAKES.

As their food consists of living prey, most snakes can not be killed by poisoned baits. The only method thus far devised seems to be to kill them by clubbing or shooting. During the winter months most of our snakes are in a torpid condition. Late in spring, however, and after the ground has become warmed up, Rattlesnakes and Copperheads make their appearance. In spring the colony for an entire neighborhood can be destroyed if the rocky ledge beneath which they have wintered or other hibernating retreat is located. Here in the early days of March and April they lie in the sun and are so sluggish that they may be easily dispatched with a club. Later in spring they spread out to the fields and the hillsides in search of mice, small birds, and other prey.

Where conditions are favorable for the running of hogs these animals may be employed; this method has been reported by a number of observers as satisfactory in reducing the numbers of snakes. Water Moccasins are so abundant in the swamp lands of our Southern and Gulf States that control measures are practically impossible. They are not so plentiful in the cultivated sections, and should be destroyed wherever encountered. Because of their burrowing habits, Harlequin Snakes are not often observed; they are apparently quite rare in most sections of the South and are most frequently seen at the time sweet potatoes are dug.

Poisonous snakes are not without their own enemies. The Blacksnake (Coluber constrictor) and the Common Kingsnake (Lampropeltis getulus) are able to kill Rattlesnakes, and the Kingsnake is known to eat them. The stomachs of several related forms of Kingsnakes have been found to contain remains of poisonous snakes. It has been reported that skunks occasionally kill Rattlers.

FOOD HABITS.

Examination of all accessible accounts indicates that Rattlesnakes feed on any sort of smaller vertebrates which may come within their reach. The following items have been found upon examination of stomachs: Ground squirrels, chipmunks, pocket gophers, young prairie dogs, kangaroo rats, deer mice, meadow mice, and cottontail rabbits; various small lizards such as Uta, Cnemidophorus, and Gerrhonotus; frogs and toads; and occasionally birds as large as quail.

The food habits of the Copperhead and Cotton-mouth Water Moccasin, judging from published accounts, are essentially like those of the Rattlesnake, except that more aquatic vertebrates are available for the Water Moccasin.

The Harlequin Snake does most of its feeding at night, capturing young snakes and lizards, particularly skinks (Eumeces)

BIBLIOGRAPHY

Barbour, T., Rattlesnakes and spitting snakes. Copeia, No. 106, pp. 36-38, May 20, 1922.

Cope, E. D., The crocodilians, lizards, and snakes of North America. Rept. U. S. Nat. Mus. for 1893, pp. 153-1294; 1900.

Ditmars, R. L., The reptile book. A comprehensive, popularized work on the structure and habits of turtles, tortoises, crocodilians, lizards, and snakes which inhabit the United States and northern Mexico. Doubleday, Page & Co., New York. Pp. sssii+472, 8 color pls., and more than 400 photos; 1907.

Feoktistow, A. E., Eine vorläusige Mittheilung über die Wirkung des Schlangengiftes auf den thierischen Organusmus. Mem. d.l'Acad. Imp. d.Sci. de St. Petersbourg (7), vol. 36, no. 4, pp. 22; 1888.

Fitzsimons, F. W., The snakes of South Africa: their venoms and the treatment of snake bite. New ed., Longmanns Green, & Co., New York; 1912.

German, S., On the evolution of the rattlesnake. Proc. Boston Soc. Nat. Hist., vol. 24, pp. 170-182, pls. 1-2; 1889.

Mitchell, S. W., Researches upon the venom of the rattlesnake with an investigation of the anatomy and physiology of the organs concerned. Smithsonian Contrib. to Knowledge, vol. 12, pp. vii+139; 1860.

Mitchell, S. W., and E. T. Reighert, Researches upon the venoms of poisonous serpents. Smithsonian Contrib. to Knowledge, vol. 26, pp. ix+186, pl; 1886.

Noguchi, H., Snake venoms, an investigation of venomous snakes with special reference to the phenomena of their venoms. Carnegie Inst. Washington, pp. xvii+315, pls. 33; figs. 16; 1909.

Phisalix, M., Anatomie comparée de la tête et de l'appareil venimeux chez les serpents. Ann. Sci. Nat. (zool.), Paris, (9), vol. 19, pp. 1-114, figs; 1914.

---------- Recherches sur l'immunité naturelle des Vipères et des Couleuvres, Comptes Rendus Acad. Sci. Paris, tome 137, pp. 270-272; 1903; and Comptes Rendus Soc. Biol., vol. 55, pp. 1082-1085; 1903.

Stejneger, L., The poisonous snakes of North America. Rept. U. S. Nat. Mus., for 1893, pp. 337-487, pls. 1-19, figs. 70; 1895.

Tomes, C. S., On the development and succession of the poison fangs of snakes. Philos. Trans., London, vol. 166, pt. 2, pp. 377-385; 1876.

Willson, P., Snake poisoning in the United States: a study based on an analysis of 740 cases. Archives Internal Medicine, Chicago, vol. 1, pp. 516-570; 1908.

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UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF BIOLOGICAL SURVEY

POISONOUS SNAKES OF THE UNITED STATES

INTRODUCTION

Snakes are easily confused with one another, and the question as to whether a certain one is poisonous or harmless arises again and again. Poisonous snakes are provided with a specific venomous fluid and an apparatus especially adapted for the introduction of this poison into their victims. As it is usual to regard all snakes as venomous, the burden of proof is upon those believing in their innocence. So many wonderful stories concerning snakes have been current from time to time that the public in turn becomes skeptical about everything concerning snakes or firmly believes in traditional accounts that usually are highly erroneous. Allowance being made for misinterpretation of certain natural habits of reptiles, the grain of truth may be perceived in these traditions in spite of the exaggeration that ordinarily accompanies a good snake story. Nevertheless, poisonous snakes are an actual as well as a mental hazard in these days of hiking, camping, and auto picnicking.

The Elapidae, or Harlequin Snakes, are proteroglyphs and occur from South Carolina and Arizona to South America (genus Micrurus), and are frequently confused with the nonvenomous Scarlet Snake (Cemophora cocconea) and Scarlet Kingsnake (Lampropeltis elapsoides). The former differs from the Harlequin Snake (and also from the Scarlet Kingsnake, which it resembles very closely) in having the ventral surface yellowish white; the latter differs from the Harlequin in having the black cross bands less than half the width of the crimson.

The Crotalidae, or "pit-vipers," are solenoglyphs and occur throughout Temperate and Tropical America and include a number of venomous species that are familiarly known by the following names: Rattlesnakes (Crotalus spp.), the Massasauga (Sistrurus sp.), Cotton-mouth Water Moccasin (Agkistrodon piscivorus), and Copperhead (Agkistrodon mokasen). No true vipers are found on the American continents. The well-known Rattlesnakes, of which there are a number of species, are the most specialized of all the venomous snakes. The rattlesnake race has been extraordinarily adaptable, as its members have come to occupy the most diverse conditions of environment, including extremes of both humidity and aridity.

One of the Rattlesnakes is known as the Water Rattler (Crotalus adamanteus), because it is partial to the neighborhood of water and is said to be a good swimmer; yet others, the Pallid Rattler (Crotalus mitchelli), for example, live in typical deserts. The Prairie Rattler (Crotalus confluentus) occurs over the dryish areas of the Great Plains, while a related form, Crotalus horridus, is limited to the timbered areas of the eastern parts of the United States. It is certain that Rattlesnakes do not habitually climb trees, because they are poorly adapted to such an accomplishment, yet there is unquestionable proof that they do so occasionally. It requires a little more climbing ability to scale a rough-barked slanting tree than the face of a rocky ledge.

The Pigmy Rattler and the Massasauga (Sistrurus) are diminutive forms of true Rattlesnakes (Crotalus), attaining a length of nearly three feet and a thickness of less than one inch; their range is chiefly east of the Rocky Mountains, except for Arizona, and they are characteristically forms of the prairies and their swamps and marshes. The diamond-back rattlers (Crotalus adamanteus and C. atrox) are unquestionably the most excitable and most vicious of all North American pit-vipers. The Red Rattler (Crotalus exsul) is said to be the least offensive. The Cotton-mouth Water Moccasin frequents the lowlands along the southern rivers and the adjoining swamps into which the rivers overflow during high water; in its native haunts the Cotton-mouth is irritable and pugnacious, and when surprised throws its head back and opens its mouth disclosing the white lining. In the Northern States the Copperhead is partial to rocky places in the vicinity of timber, marshes, or abandoned stone quarries; in the South it frequents higher and drier ground than around the marshes; unless cornered, this snake usually attempts to escape unseen. Nevertheless, the copperhead is a rather vicious snake, giving no warning of its presence, and striking in any direction.

Key to the Poisonous Snakes of the United States

Smaller snakes, characterized by brilliant colors; markings consisting of broad alternating rings of crimson and black, separated from each other by narrower yellow rings; black bands as broad as the crimson; a pair of short, erect longitudinally grooved fangs in front of upper jaw; head as wide as neck, Coral, or Harlequin, Snakes-ELAPIDAE

Head with yellow band across center and behind this a black ring; yellow body rings very narrow. In humid places from North Carolina to Florida, and westward through Gulf States to Mexico,
Harlequin Snake-Micrurus fulvius.

Head black over greater portion; yellow band on back of head and behind this a red ring; yellow body rings broader. Southern New Mexico, Arizona, California, and Northern Mexico in region bounded by Rocky Mountains and Colorado River.... ....Sonoran Coral Snake-Micrurus euryxanthus.

Larger snakes, characterized by duller colors; markings not forming regular alternating bands but consisting of blotches, diamonds, or incomplete bands; a pair of long, hollow, freely movable fangs that fold back against roof of mouth when jaws are closed; deep pit on face between nostril and eye; scales on upper-parts keeled; pupils elliptical in shape, vertical in position; head wider than neck..... ...."Pit-Vipers"-CROTALIDAE.

Tail without rattle, ending in a point; top of head covered with shields, Agkistrodon.

Color pattern distinct; ground color pale brown (grading into pale green on tail in Texas); blotches, or cross bands, reddish brown. Massachusetts to northern Florida, westward to central Illinois, Kansas, and Texas,
Copperhead, Highland Moccasin, or Chunkhead, Poplar Leaf, and Deaf Adder.. .....Agkistrodon mokasen.

Color pattern obscure; ground color light to dark brown; cross bands darker, often indistinct and bordered with yellow spots;

some of ventral scales on tail undivided. Lowlands from southeastern Virginia to Florida and Gulf States northward through Mississippi Valley to southeastern Missouri and southern Illinois, and westward through Texas to the Rio Grande,
Cotton-mouth Water Moccasin-Agkistrodon piscivorus.

Tail with rattle..... .....Sistrurus and Crotalus.

A single large scale on top of head between supraocular scales (those over eyes).....Sistrurus.

Size small; ground color grayish; large black blotches on back, smaller series on sides. Southeastern North Carolina to Florida, west through Gulf States to western Texas and Oklahoma, northward through Mississippi Basin to Arkansas and southern Missouri.
Ground Rattler, or Pigmy Rattlesnake-Sistrurus miliarius.

Size medium; ground color brownish; large black blotches on back in close formation. Western New York to southern Ontario and southern peninsula of Michigan, southward to southeastern Arizona and northeastern Mexico,
Massasauga-Sistrurus catenatus catenatus
and Sistrurus catenatus edwardsii.

Many small scales on top of head between supraocular scales (those over eyes)..... .....Crotalus.

The genus Crotalus has 13 species in the United States, but the characteristics distinguishing these Rattlesnakes are too technical for presentation here. Their scientific and vernacular names and statements of their ranges follow:

Crotalus adamanteus-Diamond-back Rattler.
About swamps from southern North Carolina to Florida and Keys, westward to Louisiana, and Arkansas.
Crotalus atrox-Western Diamond-back Rattler.
Dry rocky places as well as agricultural districts from Texas and northern Mexico to Arizona; also Lower California.
Crotalus cerastes-Horned Rattlesnake, or Sidewinder.
Sands of desert plains from northeastern Lower California, southern California, southern Utah, southwestern Nevada, and Arizona.
Crotalus confluentus-Prairie Rattler.
Great Plains from southern Canada to Texas.
Crotalus exsul-Red Rattlesnake.
Southwestern California, Mexico, Lower California, and islands in Gulf of California.
Crotalus horridus-Timber Rattler.
In woody and hilly districts from Maine to Georgia, westward to Great Plains.
Crotalus lepidus-Green Rattlesnake.
Mountains from border region of western Texas, southern New Mexico, Arizona and adjacent Mexico.
Crotalus mitchellii-Pallid, or Bleached, Rattler.
Arizona, Colorado Desert to southern Lower California.

Crotalus molossus-Dog-faced Rattler, or Black-tailed Rattler.
Southwest from western Texas to southern Arizona, also highlands of northern Mexico.
Crotalus oreganus-Pacific Rattler or Black Rattler.
British Columbia to southern California, western Idaho, Nevada, and Arizona.
Crotalus triseriatus-Spotted Rattler.
Mountains of southern Arizona and central plateau of Mexico.
Crotalus tigris-Tiger Rattler.
Southern California, southern Nevada, and Arizona.
Crotalus willardi-Rattler.
Santa Rita Mountain region Arizona, and northern Mexico.

POISON APPARATUS OF VENOMOUS SNAKES

The fluid, or venom, is injected into the snake's victim by means of specialized teeth on the maxillary bone of the upper jaw, which differ from normal reptilian teeth by having a groove, or canal, from base to apex. These venom fangs are large and readily observed. The canals of the fangs are fed with fluid from poison glands by means of excretory ducts that connect with the latter. Venom does not flow freely except when the snake is actually striking, for the end of the duct, which is not in contact with the base of the fang, is normally compressed by a sheath, or fold of the mucous membrane. A Rattlesnake may open its mouth to fullest extent and may or may not erect the fangs. The snake apparently has perfect control over its fangs, raising or depressing them at will. Introduction of venom is accomplished by the combined action of several muscles, which open the mouth, erect the fangs, and compress the poison glands, thus forcing the venomous fluid through the connecting duct into and through the fangs in the brief space of time in which the snake strikes its victim.

At the end of a stroke, the fangs of a poisonous snake are quickly with drawn from the flesh for the whole action is the work of an instant. Unless the snake strikes again, the mouth closes as the fangs fold back, mechanical compression constricts the excretory duct, and pressure is relieved from the poison glands by relaxation of the enveloping muscles. A poisonous snake often miscalculates the distance of the object at which it is striking. In case the object is too close, the fangs are not fully erect when the snake strikes and hence do not penetrate. Conversely, if the thing struck at is beyond reach, the whole stroke may be completed without touching the object of attack. In this case it may happen that the venom is projected several feet, which has given rise to repeated accounts of spitting by poisonous snakes.

In human beings the bite of a venomous snake is usually followed by painful symptoms and occasionally by death. Other animals are affected in various ways. Among them the hog is reported to be immune from the bite of venomous snakes, possibly because of its thick skin and protecting layer of fat.

POISON FANGS

Though the fangs of our venomous snakes are shed frequently, it can not be said that they are shed periodically. On each side of the upper jaw there is a hollow or grooved poison fang firmly ankylosed to the maxillary bone. This pair of functional fangs is supplemented by several pairs of smaller teeth growing loosely in the flesh and buried in the soft sheath of the gum. When from any cause one of the large fangs is broken off, the reserve fang nearest to it moves over in its place, grows fast to the maxillary bone, and becomes the functional poison fang. In case of accident to either of the fangs in use there is always a reserve fang ready to replace it.

LENGTH OF STROKE

The idea that a venomous snake can strike its full length or even a greater distance is another popular but erroneous belief. When a snake strikes from its usual S-shaped curved position, the anterior half of the body, which is thrown forward, must be free from coil. In striking the snake simply straightens out the S-shaped curves. It does not have to be in this position to strike, for observation has shown that when irritated most of our poisonous snakes can strike from almost any position for short distances. The Western Diamond-back Rattler when excited frequently raises its head and the S-shaped loop 10 to 15 inches above the ground, from which position it strikes sideward and downward. When this rattler is lying coiled with its head resting on its body, it is able to strike almost vertically upward. The greatest length of stroke is about three-fourths the length of the snake.

VENOMS OF POISONOUS SNAKES

Venom is a secretion of a supralabial gland that resembles in its development the parotid (a salivary) gland in mammals, and is composed of from 50 to 70 per cent of proteins; the chief remaining components are water and carbohydrates, with occasional admixtures of abraded epithelial cells, or saprophytic micro-organisma, while salts such as chlorides, phosphates of calcium, magnesium, and ammonium occur in small quantities. The reaction of venom to litmus is usually acid; in some cases neutral. The venoms of the different species of poisonous snakes differ to a greater or lesser degree, though all venoms are multiple in nature, that is, they contain several toxins that act independently of one another. Warm-blooded animals are usually more susceptible to venom than cold-blooded. Dried venom retains its original toxic properties in unaltered strength and quality for an indefinite period. Dr. S. Weir Mitchell found that venom kept dry for 23 years was unaltered in these respects. In a fresh state the venom of a snake is a somewhat viscid fluid of a yellowish color. The specific gravity of the venom of our poisonous snakes, according to Mitchell, is as follows: Crotalus horridus, 1.054, C. atrox, 1.077; C. adamanteus, 1.061; Agkistrodon piscivorus, 1.032.

The effect of venom on the victim is due to the complicated action of several toxic elements, of which neurotoxins and hemorrhagins (explained below) are the most important. Neurotoxins have a destructive action upon the nervous system and play the most important part in producing the death of a victim of venom poisoning. They are present in relatively large proportions and are the chief death-dealing factors in the venom of the Harlequin Snake (Micrurus),

one of the smaller poisonous snakes of the family Elapidae. Rattlesnakes (Crotalus and Sistrurus) and Mocassins (Agkistrodon) of the family Crotalidae produce neurotoxin in comparatively small quantities. The venom of the Cottonmouth Water Moccasin contains more neurotoxin than that of the Rattlesnake, and consequently its paralytic effect on the respiratory center and motor nerves is stronger. This toxin not only breaks down the nuclei of the ganglion (nerve center) cells but produces granular disintegration of the sheath (myelin) and fragmentation of the conducting portions (axis cylinder) of the nerve fibers. These neurotoxins offer a high resistance to heat and retain their toxic properties after prolonged treatment with alcohol.

The hemorrhagins constitute the chief toxic constituents of rattlesnake venom and have a solvent action on the endothelial cells composing the walls of the blood and lymph vessels, particularly the smallest of them known as capillaries. One of the most alarming symptoms ensuing from the bite of a pit-viper is the enormous swelling and extravasation of blood around the wound. The blood escapes from the blood vessels through holes in the walls, for the walls of the vessels are really dissolved away in places. Red blood cells as well as white escape upon dissolution of the walls of the blood vessels.

The venoms of different species of snakes dissolve the red blood cells also in a similar fashion. This cell-dissolving substance that has a peculiarly destructive effect on red blood cells is called hemolysin. In dogs inoculated with venom the hemoglobin contained in the red blood cells readily crystalizes. It has been found in animals dying from suppression of urine after being bitten that the tubules of the kidneys are often completely blocked with hemoglobin crystals. The activities of the white blood cells (leucocytes) also are suspended by the action of the venom. Moreover, it has been found that venom contains elements that are agglutinating as well as dissolving for the white cells and that these are distinct from those that affect the red blood cells.

Biochemical studies have shown that snake venom possesses four distinct classes of ferment-like substances apart from the cell dissolvers (cytolysins), and these are the fibrin ferment, and the proteolytic, diastatic, and lipolytic enzymes. One of the most remarkable features resulting from the bite of either the Rattlesnake or the Moccasin is the loss or the reduction of capacity of the blood for coagulation; it has been found that venom contains a powerful ferment that attacks the fibrin (the coagulating element) of the blood. The proteolytic enzyme of snake venom results in the softening of the muscles; the diastatic enzyme activates the inactive pancreatic juice, enabling it energetically to attack albuminoids; the fourth enzyme has a feeble lipolytic (fat dissolving) action in the splitting of lecithin and in fatty degeneration in the liver.

The quantity of venom yielded at any one time by our venomous snakes varies, in general, in proportion to the size and age of the snake, the length of the period of fasting or hibernation, and other environmental conditions. The pit-vipers never inject the entire contents of their glands at a single thrust, the amount injected varying from 25 to 75 per cent of the total, usually about 50 per cent. The following table, prepared by Dr. Afranio do Amaral (1928), gives the dry weight of a single extractable dose from both glands, presumably about twice the quantity injected by the snakes at one thrust:

Species	Young specimens		Adult specimens		Old specimens		Exceptional specimens	
	Liquid	Dried	Liquid	Dried	Liquid	Dried	Liquid	Dried
	cc.	grams	cc.	grams	cc.	grams	cc.	grams
Copperhead (Agkistrodon mokasen)..	0.14	0.040	0.18	0.050	0.21	0.060	0.26	0.075
Water Moccasin (Agkistrodon piscivorus)	0.32	0.090	0.42	0.120	0.53	0.150	1.05	0.300
E.Diamond-back Rattler (Crotalus adamanteus)	0.84	0.240	1.05	0.300	2.10	0.600	2.65	0.750
W.Diamond-back Rattler (Crotalus atrox).....	0.30	0.090	0.40	0.120	0.80	0.240	2.00	0.600
Horned Rattler (Crotalus cerastes)...	0.04	0.012	0.06	0.018	--	--	--	--
Prairie Rattler (Crotalus confluentus).	0.18	0.050	0.32	0.090	--	--	--	--
Red Rattler (Crotalus exsul).....	0.36	0.120	0.72	0.240	1.35	0.450	1.65	0.550
Banded Rattler (Crotalus horridus)...	0.21	0.060	0.32	0.090	0.63	0.180	--	--
Green Rattler (Crotalus lepidus)....	--	--	0.1	0.03	--	--	--	--
Bleached Rattler (Crotalus mitchellii)..	0.18	0.060	0.30	0.100	0.48	0.160	0.80	0.265
Black-tail Rattler (Crotalus molossus)....	--	--	0.60	0.180	--	--	--	--
Pacific Rattler (Crotalus oreganus)....	0.14	0.040	0.23	0.065	0.32	0.090	0.44	0.125
Tiger Rattler (Crotalus tigris.....	--	--	0.18	0.060	--	--	--	--
Pigmy Rattler (Sistrurus miliarius)..	--	--	0.08	0.02	--	--	--	--

The solid substances thus represent from 25 to 35 per cent of the total weight of the venom of North American species of pit vipers. Flexner and Noguchi found the solid portion of venom (Crotalus and Agkistrodon) to range from 50 to 70 per cent of the total weight. Amaral contends that Flexner and Noguchi must have used snakes with infected mouths (purulent venom) or at least have made an error in their calculations of the solid stuffs in the venom. Since one avoirdupois ounce equals 28.35 grams, the maximum dose of venom, according to the foregoing table, would be about one thirty-eighth of an ounce.

Mitchell published the following observations on the quantity of venom yielded by four rattlesnakes:

Length, 18 inches; weight, 9 1/2 ounces; capacity of gland, 11 drops.
Length, 25 inches; weight 18 ounces; capacity of gland, 19 drops.
Length, 49 1/2 inches; weight, 3 pounds 2 ounces; capacity of gland, 29 drops.
Length, 8 1/2 feet ejected 1 1/2 drams of venom at single bite.

Thus the actual quantity of venom injected into a victim depends largely on the size of the snake, the length of time during which its supply has been accumulating, the depth to which the fang is thrust into the flesh, as well as on the location of the bite. In the majority of cases, human beings recover without any treatment, for the reason that the quantity of venom injected is not a fatal dose.

Mitchell repeatedly pointed out the danger of secondary bacterial infection in victims surviving the primary effects of snake poisoning, and W. H. Welch, in 1893, discovered that rattlesnake venom causes blood to lose its bactericidal power. Normal blood serum destroys thousands of bacteria, while venomized serum does not possess this power.

Some knowledge of the action of crotaline venoms is of greatest importance to American physicians, since 99 per cent of the cases of snake bite treated in the United States are caused by pit-vipers.

MORTALITY RESULTING FROM SNAKE BITE

The average mortality from bites of the American venomous snakes was estimated by Willson in 1908 as little more than 10 per cent, and he considered fatalities as extremely rare. A recent study carried on by the Antivenin Institute of America under the direction of Afranio do Amaral (1927) has shown, however, that the danger from snake bite has been underestimated. It was found that in the course of one year (July, 1926, to June, 1927) in Texas something like 150 cases were reported. Of these antivenin was given in 83 cases, with 78 recoveries and 5 deaths, the death rate being 6 per cent. The death incidence was higher than would have been the case had the antivenin been administered sooner. In the remaining 67 cases in which antivenin was not injected, 23 died, the death rate being 34.3 per cent. In the Northeastern States it has been estimated that the mortality rates are from 10 to 18 per cent of those bitten, the increase being largely due to the copperhead. In the Southeastern States, Georgia, Florida, and Alabama, the average mortality rates are from 18 to 25 per cent. In Texas, New Mexico, and Arizona the death rate is somewhat higher, no doubt because of the presence of the western diamond-back rattler (Crotalus atrox), and ranges from 25 to 35 per cent of those bitten.

Estimates ranging from 100 to 1,500 cases in the United States each year of persons bitten by venomous snakes show the present uncertainty that exists in regard to the prevalence of accidents of this sort. In the majority of the reported cases the victim was bitten on the foot or leg, indicating that a high degree of protection can be obtained by wearing high-topped shoes or heavy leggings. Quail hunters in the swamps and prairies of the South will find that the best protection is afforded by a pair of waist-high rubber wading boots with special inserted canvas shank. In most cases a pair of leather puttees worn over leather shoes will give the necessary protection against snake bites. Indications are at present that Rattlesnakes are increasing in numbers in agricultural districts because of the abundance of rodent food.

The tendency of Rattlesnakes to rattle whenever disturbed and to continue the rattling as long as the disturbing influence is present also explains why victims are not more numerous. The Timber Rattler has been known to keep up its rattle for half an hour with a few intermittent momentary pauses. The fact

that the Water Moccasin lives in unfrequented swamps, and that the Harlequin Snake is of burrowing habits and has a mouth of small size, accounts for the infrequency of bites of these species.

In fatal cases, the time intervening between the bite and death varies in different species. Cases terminating fatally within a few minutes do occur, though fortunately are very rare. There is a record (Roberts) that a boy seven years of age was bitten by a Rattlesnake on the cheek below the eye and pitched forward dead before an eye witness could reach him. A little girl three years old was bitten on the forehead by a large rattlesnake died within 10 minutes (Blackwood). An analysis of 50 fatal cases resulting from the bites of American venomous snakes showed that 8 persons died in less than one hour, 13 between one and six hours, 18 in from one to twenty-four hours, 4 died on the second day, 4 died between the third and seventh days, 1 at end of nine days, 1 at end of seventeen days, and 1 lived over a month. The duration of illness following snake bite is subject to the widest variation, though in the majority of cases recovery from the constitutional disturbances is complete in two or three days, and in many cases in a few hours. Cases in which illness is prolonged are septic in character and are rarely, if ever, due to the primary action of the venom. The most important complications of snake bite are produced by the absorption of putrefactive substances (sepsis) and by acute alcoholism, resulting from mistaken treatment.

The bites of Pigmy Rattlers and Massassaugas (Sistrurus) are practically never fatal to adults, except possibly through septic complications. These rattlers are our least poisonous snakes, for of 20 cases on record none ended fatally. Of 408 persons bitten by Rattlesnakes (Crotalus) 48 died; on the other hand, of 8 persons bitten by the Harlequin Snake (Micrurus) 6 died. Of 97 cases of bites by the Copperhead (Agkistrodon makasen) 5 ended fatally, while 9 persons out of 53 bitten by the Cotton-mouth Water Moccasin (Agkistrodon piscivorus) died. When death results from the bite of the Harlequin Snake (Micrurus), it is usually between 18 and 24 hours after the bite. Symptoms of drowsiness and general depression appear within an hour or so, but if the victim survives three or four days, the danger of death passes away.

It is known that bites on the head and trunk are more dangerous than elsewhere, and that the mortality rate for bites on the upper extremities is practically double that for the lower. From 60 to 90 per cent of the total number of cases result from bites on feet or legs. The mortality in children under 10 years of age bitten by our venomous snakes is at least double that of adults.

The total number of deaths each year resulting from the bites of our venomous snakes represents a very low mortality and indicates that these snakes are not so dangerous a pest as has often been assumed. This does not mean that one should needlessly take chances of being bitten by a Rattlesnake, for the bite, when not fatal, is followed by exceedingly painful symptoms and often impairment of the part bitten. Young Rattlesnakes only five or six inches long are capable of injecting venom in quantities sufficient to require treatment.

SNAKES COMMITTING SUICIDE

It has been stated that rattlesnakes are susceptible to their own poison and that death has ensued from the effects of their self-inflicted wounds. There is a possibility, however, that the fang in such cases may have punctured the spinal nerve or some vital organ, and that death, therefore, is not invariably due to the poison. Snakes are not likely to bite themselves except when severely injured or when infuriated and unable to wreak vengeance on the tormentor. C. Phisalix has made experiments on the natural immunity of snakes from their own poison.

TREATMENT FOR BITES OF NORTH AMERICAN POISONOUS SNAKES

There can be no doubt that the chief precaution to take in case of snake bite is to prevent systemic absorption of a fatal dose of venom from the quantity contained in the tissues immediately surrounding the wound. To accomplish this, action must be prompt. Place a ligature or tourniquet above the bite (i.e. between the bite and the heart). This will delay absorption of venom, but the ligature must be loosened for a few seconds at five or ten minute intervals to maintain necessary circulation in the limb and to prevent gangrenous mortification.

Local treatment is of greatest importance, and in addition the patient should be kept warm and as quiet as possible. Mechanical means also may be employed, such as bandaging, abdominal compression, and posture to keep up blood pressure and circulation in the vital centers.

The use of strychnine and caffein usually should be avoided because of danger of increasing hemorrhage through accelerated circulation and rise of blood pressure, but they may be used if symptoms of weakness or giddiness develop. In acute cases, when the venom has been injected directly into a blood vessel, the chances of recovery are slight. In such cases, and as a last resort, intravenous injections of strychnine may be employed to stimulate the nervous centers as speedily as possible. The injection of ammonia is useless and is often followed by serious complications.

ANTIVENIN

In former years manufacturers of serums and allied preparations regarded the use of antivenins as an impracticable method of treatment in the United States. The Rockefeller Institute for Medical Research carried on experiments with antivenins and prepared small quantities of serum for use in emergencies. It was generally held that an intravenous injection of from 10 to 20 times as much antivenin as the quantity of venom injected by the snake was required to counteract or neutralize the poisonous effects of the bite of a venomous snake. The poisonous snakes of the United States were grouped roughly into three categories according to the type of venom they possessed, and it was believed that three distinct antivenins would be required to provide treatment for cases occurring within the boundaries of the United States.

Recent research has shown that a polyvalent serum could be produced that would be effective for all types of crotaline snakes, or pit-vipers, in the United States, but that persons bitten by coral snakes would have to resort to some other method of treatment. The United States Public Health Service advises that the firm of H. K. Mulford Co., Broad & Wallace Streets, Philadelphia, Pa., recently has been licensed for the production and sale of antivenin, marketed under the name "Antivenin (Nearctic Crotalidae)". So far as known, this is the only concern whose agencies in the United States are marketing a serum effective against the bites of poisonous snakes. The serum for the North American Pit-Vipers (rattlesnakes, copperheads, and water moccasins) is a concentrated antivenin supplied in doses of 10 cc. put up in sterile syringes. The package includes a glass-inclosed sterile hypodermic needle and other accessories. Complete directions are given for assembling syringe and for making the injection, so that self treatments may be given in an emergency if no medical assistance can be obtained. This 'Antivenin' is a purified and concentrated serum globulin obtained from horses that have been highly immunized against bites of North American pit-vipers. The horses are inoculated by small injections of snake venom, which are gradually increased in strength until they are able to withstand the injection of pure venom in quantities that under ordinary conditions would prove fatal. Antitoxins that neutralize the effects of the venom are produced in the blood of the inoculated horse. The blood of the immunized horse is extracted by humane methods and this is put through a process that separates the serous or colorless portion from the remainder. In this concentrated serum, the serum proteins have been eliminated as they are unnecessary, and this allows the injection of a full dose in a small quantity of liquid. An unconcentrated serum is prepared by the same firm for veterinary use, but the above-mentioned product can be employed for animals also.

If antivenin is available for injection at time the person is bitten, no tourniquet is necessary. In self treatment, injections may be made either under the skin of the thigh or preferably on the side of the abdomen. If administered by someone else, intramuscular injection should be given under the skin of the back between the shoulders. In cases where it is possible to inject the antivenin within an hour or two after the person has been bitten, about one-fifth of the contents of the syringe tube should be introduced subcutaneously locally around the fang punctures. This minimizes local destruction of tissues. In such cases the wound should be cleansed first with soap and water and treated with tincture of iodine. In cases of delayed treatment local injection will have little effect. Intravenous injection is advised in cases where the patient exhibits severe symptoms or in which treatment has been unduly delayed. The number of injections necessary to control the action of the venom depends upon the size of individual and delay in treatment. Children require more antivenin than adults, and it is often advisable to inject two, three, or even four doses. Whenever there is reason to believe that an unusually large quantity of venom was injected by the snake or when severe symptoms quickly develop, it is advisable to give additional injections. The tourniquet should be released as soon as the antivenin is injected. North American pit-viper venoms are generally slow in acting, and in most cases 'Antivenin' can be obtained in time to be effective.

POTASSIUM PERMANGANATE

Another means of minimizing absorption of the venom formerly rather extensively employed, was to make a local incision of the area immediately surrounding the puncture made by each of the fangs. It was also the practice, after the fang punctures had been cut and a free flow of blood obtained, to wash the wound carefully with a strong solution of potassium permanganate. Another method frequently employed was to inject an aqueous solution of potassium permanganate with a hypodermic syringe into the puncture of each fang and then open the punctures with a knife as directed above. Potassium permanganate will neutralize about its own weight of venom and is effective against every class of snake venom. It has been demonstrated, however, that to have any neutralizing effect on the venom, potassium permanganate must be used in concentrations that are injurious to tissues. Weak solutions are ineffective and strong solutions are themselves toxic.

It is conceivable that persons will continue to be bitten when 'Antivenin' is not on hand nor available locally, and in such cases some method of neutralizing or oxidizing the venom must be adopted. Even though resort must be made to such heroic measures as local cutting and introduction of crystals of potassium permanganate, it is advisable to take such steps. The use of potassium permanganate and the free flow of blood will at least reduce systematic absorption of the venom and may be followed by inoculation with 'Antivenin', if necessary. Such measures, however, are unnecessary if 'Antivenin' is available, for recent research seems to indicate that it is advisable to avoid mutilation of the surrounding tissues, which seems to increase the possibility of secondary infection, such as tetanus.

Several types of emergency kits are being sold in this country, including a simple but effective lance attached to a container holding crystals of potassium permanganate. The crystals will counteract the action of all types of venom if used promptly, but an antivenin injection is usually effective as late as 12 to 24 hours after person has been bitten, while such is not the case for solutions of potassium permanganate.

The list of remedies that have been used in cases of snake bite, includes almost everything conceivable, from local applications of cloths saturated with urine to poultices made by splitting open living chickens. In the past, alcohol, in the forms of wine, whiskey, and brandy has been freely administered, although there has been no foundation for its use except popular belief. Certain investigators demonstrated that the absorbed venom is eliminated in part by the stomach, and it was thought therefore that the venom could be precipitated by the alcohol before its reabsorption. Recent experiments have shown that alcohol precipitates venom but does not impair its toxic properties. By increasing the blood pressure, and in large doses intensifying coma, alcohol has a distinctly injurious influence on the victim of poisonous snakes.

RATTLES

According to popular superstition a Rattlesnake acquires a new ring on the rattle each year, and hence the number of rings composing the rattle was supposed to indicate the age of the reptile. This notion is wholly incorrect, for the Rattlesnake adds from two to four rings each year, usually three. Under normal conditions one ring is added each time the snake sheds its skin. The young Rattler is provided with a single button at birth, and within a few days it sheds its skin and commences feeding; in about two months it sheds its skin for the second time and then the first ring of the rattle is uncovered or added. This has been growing under the old skin, and its presence was apparent in the swollen appearance of the tail at the base of the original button. The last seven or eight vertebrae fuse together shortly after birth and form a composite bone known as the "shaker," and it is around this bone that each cap or ring of the rattle forms.

All of our snakes have the habit of shedding their skin one or more times during the year. The shed skin usually comes off entire, so that from head to tail it forms but a single piece of a very thin transparent material and is generally turned inside out. That part of the skin that covers the cap on the tail can not be shed on account of its peculiar shape. At the time the skin is shed, however, it is loosened and dislodged from its place and moves backward to become an additional ring on the rattle. Thus the rattle of the Rattlesnake is simply a series of shed caps or rings, held together mechanically and loosely because of their shape. The rattle seldom numbers more than ten rings because the vibration at the tip is so great that the terminal rings are soon worn down or broken off.

It has often been asserted that nature equipped the Rattlesnake with this rattle to warn enemies away from its death-dealing fangs. A more reasonable explanation seems to be that the rattle is used as a call during the breeding season, and several naturalists have borne witness to this interpretation. Inasmuch as the range of the buffalo coincided in a general way with the distribution of the Rattlesnake, the rattling of the tail was at least of mutual advantage to both, even though the actual evolution of the rattle was in no way associated with the need of such an organ. The wide-ranging herds of grazing buffalo certainly accounted for a large number of snakes in the course of a season, and any creature that happened to be in the path of a herd would have a better opportunity to escape from being trodden down if it possessed some warning device. The idea that the Rattlesnake can not rattle when its rattles are wet from swimming or being in wet grass or rainstorms, is incorrect.

YOUNG

Early in fall the female Rattlesnake brings forth from six to nine young of about five inches in length, the eggs having been retained in her body until hatched. The young display all the traits of the adults, and will try to rattle and bite as soon as they are born.

The Copperhead and the Water Moccasin are known to give birth to young during the month of July, and a litter averages from seven to nine.

Unlike the pit-vipers, the Harlequin Snake is oviparous and deposits its eggs late in May or early in June in decaying bark or damp soil. As many as seven eggs have been found together.

FOOD HABITS

Examination of all accessible accounts indicates that Rattlesnakes feed on any sort of smaller vertebrates that may come within their reach. The following items have been found upon examination of stomachs: Ground squirrels, chipmunks, pocket gophers, young prairie dogs, kangaroo rats, deer mice, meadow mice, and cottontail rabbits; various small lizards such as Uta, Cnemidophorus, and Gerrhonotus; frogs and toads, and occasionally birds as large as quail.

The food habits of the Copperhead and Cotton-mouth Water Moccasin, judging from published accounts, are essentially like those of the Rattlesnake, except that more aquatic vertebrates are available for the Water Moccasin.

The Harlequin Snake does most of its feeding at night, capturing young snakes and lizards, particularly skinks (Eumeces).

BIBLIOGRAPHY

Amaral, A. do, A general consideration of snake poisoning and observations on neotropical pit-vipers. Contrib. Harvard Institute for Tropical Biology and Medicine, II, 64 p., 16 pls. 1925.

---------- Notes on Nearctic poisonous snakes and treatment of their bites. Bul. Antivenin Institute of America, vol. 1, no.3, p. 61-76, figs. 1-30. 1927.

----------The anti-snake-bite campaign in Texas and in the sub-tropical United States. Bul. Antivenin Institute of America, vol. 1, no.3, p.77-85. 1927.

---------- Studies on snake venoms. Amounts of venom secreted by nearctic pit-vipers. Bul. Antivenin Institute of America, vol. 1, no. 4, p. 103-104. 1928.

Barbour, T., Rattlesnakes and spitting snakes. Copeia, no. 106, p. 36-38. May 20, 1922.

Cope, E. D., The crocodilians, lizards, and snakes of North America. Rept. U.S. Nat. Mus. for 1898, p. 153-1294. 1900.

Ditmars, R. L., The reptile book. A comprehensive, popularized work on the structure and habits of turtles, tortoises, crocodilians, lizards, and snakes which inhabit the United States and northern Mexico. Doubleday, Page & Co., New York.xxxii+472 p., 8 color pls., and more than 400 photos. 1907.

Feoktistow, A.E., Eine vorläusige Mittheilung über die Wirkung des Schlangengiftes auf den thierischen Organusmus. Mem. d.l'Acad. Imp. d.Sci. de St. Petersbourg (7), vol. 36, no.4, 22 p. 1888.

Fitzsimons, F. W., The snakes of South Africa, their venom and the treatment of snake bite. T. M. Miller, Cape Town, p. xvi + 550. 1921.

German, S., On the evolution of the rattlesnake. Proc. Boston Soc. Nat. Hist., vol. 24, p. 170-182, pls. 1-2. 1889.

Mitchell, S. W., Researches upon the venom of the rattlesnake with an investigation of the anatomy and physiology of the organs concerned. Smithsonian Contrib. to Knowledge, vol. 12, vii + 139 p. 1860.

Mitchell, S. W., and E. T. Reighert, Researches upon the venoms of poisonous serpents. Smithsonian Contrib. to Knowledge, vol. 26, ix + 186 p., pl. 1886.

Noguchi, H., Snake venoms, an investigation of venomous snakes with special reference to the phenomena of their venoms. Carnegie Inst. Washington. Pub. No. 111, xvii + 315 p.,33 pls. figs. 16. 1909.

Phisalix, M., Anatomie comparée de la tête et de l'appareil venimeux chez les serpents. Ann. Sci. Nat. (zool.), Paris, (9), vol. 18, p. 1-114, figs. 1914.

---------- Recherches sur l'immunité naturelle des Vipères et des Couleuvres, Comptes Rendus Acad. Sci. Paris, tome 137, p. 270-272. 1903; and Comptes Rendus Soc. Biol., vol. 55, p. 1082-1085. 1903.

Stejneger, L., The poisonous snakes of North America. Rept. U. S. Nat. Mus. for 1893, p. 338-487, pls. 1-19, 70 figs. 1895.

Tomes, C. S., On the development and succession of the poison fangs of snakes. Philos. Trans. London, vol. 166, pt. 2, p. 377-385. 1876.

Willson, P., Snake poisoning in the United States; a study based on an analysis of 740 cases. Archives Internal Medicine, Chicago, vol. 1, p. 516-570. 1908.

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UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF BIOLOGICAL SURVEY

POISONOUS SNAKES OF THE UNITED STATES

INTRODUCTION

Snakes are easily confused with one another, and the question as to whether a certain one is poisonous or harmless arises again and again. Poisonous snakes are provided with a specific venomous fluid and an apparatus especially adapted for the introduction of this poison into their victims. As it is usual to regard all snakes as venomous, the burden of proof is upon those believing in their innocence. So many wonderful stories concerning snakes have been current from time to time that the public in turn becomes skeptical about everything concerning snakes or firmly believes in traditional accounts that usually are highly erroneous. Allowance being made for misinterpretation of certain natural habits of reptiles, the grain of truth may be perceived in these traditions in spite of the exaggeration that ordinarily accompanies a good snake story. Nevertheless, poisonous snakes are an actual as well as a mental hazard in these days of hiking, camping, and auto picnicking.

The Elapidae, or Harlequin Snakes, are proteroglyphs and occur from South Carolina and Arizona to South America (genus Micrurus), and are frequently confused with the nonvenomous Scarlet Snake (Cemophora coccinea) and Scarlet Kingsnake (Lampropeltis elapsoides). The former differs from the Harlequin Snake (and also from the Scarlet Kingsnake, which it resembles very closely) in having the ventral surface yellowish white; the latter differs from the Harlequin in having the black cross bands less than half the width of the crimson.

The Crotalidae, or "pit-vipers," are solenoglyphs and occur throughout Temperate and Tropical America and include a number of venomous species that are familiarly known by the following names: Rattlesnakes (Crotalus spp.), the Massasauga (Sistrurus sp.), Cotton-mouth Water Moccasin (Agkistrodon piscivorus), and Copperhead (Agkistrodon mokasen). No true vipers are found on the American continents. The well-known Rattlesnakes, of which there are a number of species, are the most specialized of all the venomous snakes. The rattlesnake race has been extraordinarily adaptable, as its members have come to occupy the most diverse conditions of environment, including extremes of both humidity and aridity.

One of the Rattlesnakes is known as the Water Rattler (Crotalus adamanteus), because it is partial to the neighborhood of water and is said to be a good swimmer; yet others, the Pallid Rattler (Crotalus mitchellii), for example, live in typical deserts. The Prairie Rattler (Crotalus confluentus) occurs over the dryish areas of the Great Plains, while a related form, Crotalus horridus, is limited to the timbered areas of the eastern parts of the United States. It is certain that Rattlesnakes do not habitually climb trees, because they are poorly adapted to such an accomplishment, yet there is unquestionable proof that they do so occasionally. It requires a little more climbing ability to scale a rough-barked slanting tree than the face of a rocky ledge.

The Pigmy Rattler and the Massasauga (Sistrurus) are diminutive forms of true Rattlesnakes (Crotalus), attaining a length of nearly three feet and a thickness of less than one inch; their range is chiefly east of the Rocky Mountains, except for Arizona, and they are characteristically forms of the prairies and their swamps and marshes. The Diamond-back Rattlers (Crotalus adamanteus and C. atrox) are unquestionably the most excitable and most vicious of all North American pit-vipers. The Red Rattler (Crotalus exsul) is said to be the least offensive. The Cotton-mouth Water Moccasin frequents the lowlands along the southern rivers and the adjoining swamps into which the rivers overflow during high water; in its native haunts the Cotton-mouth is irritable and pugnacious, and when surprised throws its head back and opens its mouth disclosing the white lining. In the Northern States the Copperhead is partial to rocky places in the vicinity of timber, marshes, or abandoned stone quarries; in the South it frequents higher and drier ground than around the marshes; unless cornered, this snake usually attempts to escape unseen. Nevertheless, the Copperhead is a rather vicious snake, giving no warning of its presence, and striking in any direction.

Key to the Poisonous Snakes of the United States

Smaller snakes, characterized by brilliant colors; markings consisting of broad alternating rings of crimson and black, separated from each other by narrower yellow rings; black bands as broad as the crimson; a pair of short, erect longitudinally grooved fangs in front of upper jaw; head as wide as neck, Coral, or Harlequin, Snakes-ELAPIDAE.

Head with yellow band across center and behind this a black ring; yellow body rings very narrow. In humid places from North Carolina to Florida, and westward through Gulf States to Mexico,
Harlequin Snake-Micrurus fulvius.

Head black over greater portion; yellow band on back of head and behind this a red ring; yellow body rings broader. Southern New Mexico, Arizona, California, and Northern Mexico in region bounded by Rocky Mountains and Colorado River.... ....Sonoran Coral Snake-Micrurus euryxanthus.

Larger snakes, characterized by duller colors; markings not forming regular alternating bands but consisting of blotches, diamonds, or incomplete bands; a pair of long, hollow, freely movable fangs that fold back against roof of mouth when jaws are closed; deep pit on face between nostril and eye; scales on upper-parts keeled; pupils elliptical in shape, vertical in position; head wider than neck......"Pit-Vipers"-CROTALIDAE.

Tail without rattle, ending in a point; top of head covered with shields, Agkistrodon.

Color pattern distinct; ground color pale brown (grading into pale green on tail in Texas); blotches, or cross bands, reddish brown. Massachusetts to northern Florida, westward to central Illinois, Kansas, and Texas,
Copperhead, Highland Moccasin, or Chunkhead, Poplar Leaf, and Deaf Adder.. .....Agkistrodon mokasen.

Color pattern obscure; ground color light to dark brown; cross bands darker, often indistinct and bordered with yellow spots;

some of ventral scales on tail undivided. Lowlands from southeastern Virginia to Florida and Gulf States northward through Mississippi Valley to southeastern Missouri and southern Illinois, and westward through Texas to the Rio Grande,

Cotton-mouth Water Moccasin-Agkistrodon piscivorus.

Tail with rattle .....Sistrurus and Crotalus.

A single large scale on top of head between supraocular scales (those over eyes)..... Sistrurus.

Size small; ground color grayish; large black blotches on back, smaller series on sides. Southeastern North Carolina to Florida, west through Gulf States to western Texas and Oklahoma, northward through Mississippi Basin to Arkansas and southern Missouri.

Ground Rattler, or Pigmy Rattlesnake-Sistrurus miliarius.

Size medium; ground color brownish; large black blotches on back in close formation. Western New York to southern Ontario and southern peninsula of Michigan, southward to southeastern Arizona and northeastern Mexico,

Massasauga-Sistrurus catenatus catenatus and Sistrurus catenatus edwardsii.

Many small scales on top of head between supraocular scales (those over eyes) .....Crotalus.

The genus Crotalus has 13 species in the United States, but the characteristics distinguishing these Rattlesnakes are too technical for presentation here. Their scientific and vernacular names and statements of their ranges follow:

Crotalus adamanteus-Diamond-back Rattler.
About swamps from southern North Carolina to Florida and Keys, westward to Louisiana and Arkansas.

Crotalus atrox-Western Diamond-back rattler.
Dry rocky places as well as agricultural districts from Texas and northern Mexico to Arizona; also Lower California.

Crotalus cerastes-Horned Rattlesnake, or Sidewinder.
Sands of desert plains from northeastern Lower California, southern California, southern Utah, southwestern Nevada, and Arizona.

Crotalus confluentus-Prairie Rattler.
Great Plains from southern Canada to Texas.

Crotalus exsul-Red Rattlesnake.
Southwestern California, Mexico, Lower California, and islands in Gulf of California.

Crotalus horridus-Timber Rattler.
In Woody and hilly districts from Maine to Georgia, westward to Great Plains.

Crotalus lepidus-Green Rattlesnake.
Mountains from border region of western Texas, southern New Mexico, Arizona and adjacent Mexico.

Crotalus mitchellii-Pallid, or Bleached, Rattler.
Arizona, Colorado Desert to southern Lower California.

Crotalus molossus-Dog-faced Rattler, or Black-tailed Rattler.
Southwest from western Texas to southern Arizona, also highlands of northern Mexico.
Crotalus oreganus-Pacific Rattler or Black Rattler.
British Columbia to southern California, western Idaho, Nevada, and Arizona
Crotalus triseriatus-Spotted Rattler.
Mountains of southern Arizona and central plateau of Mexico.
Crotalus tigris-Tiger Rattler.
Southern California, southern Nevada, and Arizona.
Crotalus willardi-Rattler.
Santa Rita Mountain region Arizona, and northern Mexico.

POISON APPARATUS OF VENOMOUS SNAKES

The fluid, or venom, is injected into the snake's victim by means of specialized teeth on the maxillary bone of the upper jaw, which differ from normal reptilian teeth by having a groove, or canal, from base to apex. These venom fangs are large and readily observed. The canals of the fangs are fed with fluid from poison glands by means of excretory ducts that connect with the latter. Venom does not flow freely except when the snake is actually striking, for the end of the duct, which is not in contact with the base of the fang, is normally compressed by a sheath, or fold of the mucous membrane. A Rattlesnake may open its mouth to fullest extent and may or may not erect the fangs. The snake apparently has perfect control over its fangs, raising or depressing them at will. Introduction of venom is accomplished by the combined action of several muscles, which open the mouth, erect the fangs, and compress the poison glands, thus forcing the venomous fluid through the connecting duct into and through the fangs in the brief space of time in which the snake strikes its victim.

At the end of a stroke, the fangs of a poisonous snake are quickly with drawn from the flesh for the whole action is the work of an instant. Unless the snake strikes again, the mouth closes as the fangs fold back, mechanical compression constricts the excretory duct, and pressure is relieved from the poison glands by relaxation of the enveloping muscles. A poisonous snake often miscalculates the distance of the object at which it is striking. In case the object is too close, the fangs are not fully erect when the snake strikes and hence do not penetrate. Conversely, if the thing struck at is beyond reach, the whole stroke may be completed without touching the object of attack. In this case it may happen that the venom is projected several feet, which has given rise to repeated accounts of spitting by poisonous snakes.

In haman beings the bite of a venomous snake is usually followed by painful symptoms and occasionally by death. Other animals are affected in various ways, as in the case of the hog, which has a degree of immunity from the bite of venomous snakes, because of its thick skin and protecting layer of fat.

POISON FANGS

Though the fangs of our venomous snakes [illegible] be said that they are shed periodically. On each side of the upper jaw there is a hollow or grooved poison fang firmly ankylosed to the maxillary bone. This pair of functional fangs is supplemented by several pairs of smaller teeth growing loosely in the flesh and buried in the soft sheath of the gum. When from any cause one of the large fangs is broken off, the reserve fang nearest to it moves over in its place, grows fast to the maxillary bone, and becomes the functional poison fang. In case of accident to either of the fangs in use there is always a reserve fang ready to replace it.

LENGTH OF STROKE

The idea that a venomous snake can strike its full length or even a greater distance is another popular but erroneous belief. When a snake strikes from its usual S-shaped curved position, the anterior half of the body, which is thrown forward, must be free from coil. In striking the snake simply straightens out the S-shaped curves. It does not have to be in this position to strike, for observation has shown that when irritated most of our poisonous snakes can strike from almost any position for short distances. The Western Diamond-back Rattler when excited frequently raises its head and the S-shaped loop 10 to 15 inches above the ground, from which position it strikes sideward and downward. When this rattler is lying coiled with its head resting on its body, it is able to strike almost vertically upward. The greatest length of stroke is about three-fourths the length of the snake.

VENOMS OF POISONOUS SNAKES

Venom is a secretion of a supralabial gland that resembles in its development the parotid (a salivary) gland in mammals, and is composed of 50 to 70 per cent of proteins; the chief remaining components are water and carbohydrates, with occasional admixtures of abraded epithelial cells, saprophytic micro-organisms, while salts such as chlorides, phosphates of calcium, magnesium, and ammonium occur in small quantities. The reaction of venom to litmus is usually acid; in some cases neutral. The venoms of the different species of poisonous snakes differ to a greater or lesser degree, though all venoms are multiple in nature, that is, they contain several toxins that act independently of one another. Warm-blooded animals are usually more susceptible to venom than cold-blooded. Dried venom retains its original toxic properties in unaltered strength and quality for an indefinite period. Dr. S. Weir Mitchell found that venom kept dry for 23 years was unaltered in these respects. In a fresh state the venom of a snake is a somewhat viscid fluid of a yellowish color. The specific gravity of the venom of our poisonous snakes, according to Mitchell, is as follows: Crotalus horridus, 1.054, C. atrox, 1.077; C. adamanteus, 1.061; Agkistrodon piscivorus, 1.032.

The effect of venom on the victim is due to the complicated action of several toxic elements, of which neurotoxins and hemorrhagins (explained below) are the most important. Neurotoxins have a destructive action upon the nervous system and play the most important part in producing the death of a victim of venom poisoning. They are present in relatively large proportions and are the chief death-dealing factors in the venom of the Harlequin Snake (Micrurus),

one of the smaller poisonous snakes of the family Elapidae. Rattlesnakes (Crotalus and Sistrurus) and Mocassins (Agkistrodon) of the family Crotalidae produce neurotoxin in comparatively small quantities. The venom of the Cottonmouth Water Moccasin contains more neurotoxin than that of the Rattlesnake, and consequently its paralytic effect on the respiratory center and motor nerves is stronger. This toxin not only breaks down the nuclei of the ganglion (nerve center) cells but produces granular disintegration of the sheath (myelin) and fragmentation of the conducting portions (axis cylinder) of the nerve fibers. These neurotoxins offer a high resistance to heat and retain their toxic properties after prolonged treatment with alcohol.

The hemorrhagins constitute the chief toxic constituents of rattlesnake venom and have a solvent action on the endothelial cells composing the walls of the blood and lymph vessels, particularly the smallest of them known as capillaries. One of the most alarming symptoms ensuing from the bite of a pit-viper is the enormous swelling and extravasation of blood around the wound. The blood escapes from the blood vessels through holes in the walls, for the walls of the vessels are really dissolved away in places. Red blood cells as well as white escape upon dissolution of the walls of the blood vessels.

The venoms of different species of snakes dissolve the red blood cells also in a similar fashion. This cell-dissolving substance that has a peculiarly destructive effect on red blood cells is called hemolysin. In dogs inoculated with venom the hemoglobin contained in the red blood cells readily crystalizes. It has been found in animals dying from suppression of urine after being bitten that the tubules of the kidneys are often completely blocked with hemoglobin crystals. The activities of the white blood cells (leucocytes) also are suspended by the action of the venom. Moreover, it has been found that venom contains elements that are agglutinating as well as dissolving for the white cells and that these are distinct from those that affect the red blood cells.

Biochemical studies have shown that snake venom possesses four distinct classes of ferment-like substances apart from the cell dissolvers (cytolysins), and these are the fibrin ferment, and the proteolytic, diastatic, and lipolytic enzymes. One of the most remarkable features resulting from the bite of either the Rattlesnake or the Moccasin is the loss or the reduction of capacity of the blood for coagulation; it has been found that venom contains a powerful ferment that attacks the fibrin (the coagulating element) of the blood. The proteolytic enzyme of snake venom results in the softening of the muscles; the diastatic enzyme activates the inactive pancreatic juice, enabling it energetically to attack albuminoids; the fourth enzyme has a feeble lipolytic (fat dissolving) action in the splitting of lecithin and in fatty degeneration in the liver.

The quantity of venom yielded at any one time by our venomous snakes varies, in general, in proportion to the size and age of the snake, the length of the period of fasting or hibernation, and other environmental conditions. The pit-vipers never inject the entire contents of their glands at a single thrust, the amount injected varying from 25 to 75 per cent of the total, usually about 50 per cent. The following table, prepared by Dr. Afranio do Amaral (1928), gives the dry weight of a single extractable dose from both glands, presumably about twice the quantity injected by the snakes at one thrust:

Species	Young specimens		Adult specimens		Old specimens		Exceptional specimens	
	Liquid	Dried	Liquid	Dried	Liquid	Dried	Liquid	Dried
	cc.	grams	cc.	grams	cc.	grams	cc.	grams
Copperhead (Agkistrodon mokasen)..	0.14	0.040	0.18	0.050	0.21	0.060	0.26	0.075
Water Moccasin (Agkistrodon piscivorus)	0.32	0.090	0.42	0.120	0.53	0.150	1.05	0.300
E.Diamond-back Rattler (Crotalus adamanteus)	0.84	0.240	1.05	0.300	2.10	0.600	2.65	0.750
W.Diamond-back Rattler (Crotalus atrox).....	0.30	0.090	0.40	0.120	0.80	0.240	2.00	0.600
Horned Rattler (Crotalus cerastes)...	0.04	0.012	0.06	0.018	--	--	--	--
Prairie Rattler (Crotalus confluentus).	0.18	0.050	0.32	0.090	--	--	--	--
Red Rattler (Crotalus exsul).....	0.36	0.120	0.72	0.240	1.35	0.450	1.65	0.550
Banded Rattler (Crotalus horridus)...	0.21	0.060	0.32	0.090	0.63	0.180	--	--
Green Rattler (Crotalus lepidus)....	--	--	0.1	0.03	--	--	--	--
Bleached Rattler (Crotalus mitchellii)..	0.18	0.060	0.30	0.100	0.48	0.160	0.80	0.265
Black-tail Rattler (Crotalus molossus)....	--	--	0.60	0.180	--	--	--	--
Pacific Rattler (Crotalus oreganus)....	0.14	0.040	0.23	0.065	0.32	0.090	0.44	0.125
Tiger Rattler (Crotalus tigris.....	--	--	0.18	0.060	--	--	--	--
Pigmy Rattler (Sistrurus miliarius)..	--	--	0.08	0.02	--	--	--	--

The solid substances thus represent from 25 to 35 per cent of the total weight of the venom of North American species of pit vipers. Flexner and Noguchi found the solid portion of venom (Crotalus and Agkistrodon) to range from 50 to 70 per cent of the total weight. Amaral contends that Flexner and Noguchi must have used snakes with infected mouths (purulent venom) or at least have made an error in their calculations of the solid stuffs in the venom. Since one avoirdupois ounce equals 28.35 grams, the maximum dose of venom, according to the foregoing table, would be about one thirty-eighth of an ounce.

Mitchell published the following observations on the quantity of venom yielded by four rattlesnakes:

Length, 18 inches; weight, 9 1/2 ounces; capacity of gland, 11 drops.
Length, 25 inches; weight 18 ounces; capacity of gland, 19 drops.
Length, 49 1/2 inches; weight, 3 pounds 2 ounces; capacity of gland, 29 drops.
Length, 8 1/2 feet; ejected 1 1/2 drams of venom at single bite.

Thus the actual quantity of venom injected into a victim depends largely on the size of the snake, the length of time during which its supply has been accumulating, the depth to which the fang is thrust into the flesh, as well as on the location of the bite. In the majority of cases, human beings recover without any treatment, for the reason that the quantity of venom injected is not a fatal dose.

Mitchell repeatedly pointed out the danger of secondary bacterial infection in victims surviving the primary effects of snake poisoning, and W. H. Welch, in 1893, discovered that rattlesnake venom causes blood to lose its bactericidal power. Normal blood serum destroys thousands of bacteria, while venomized serum does not possess this power.

Some knowledge of the action of crotaline venoms is of greatest importance to American physicians, since 99 per cent of the cases of snake bite treated in the United States are caused by pit-vipers.

MORTALITY RESULTING FROM SNAKE BITE

The average mortality from bites of the American venomous snakes was estimated by Willson in 1908 as little more than 10 per cent, and he considered fatalities as extremely rare. A recent study carried on by the Antivenin Institute of America under the direction of Afranio do Amaral (1927) has shown, however, that the danger from snake bite has been underestimated. It was found that in the course of one year (July, 1926, to June, 1927) in Texas something like 150 cases were reported. Of these antivenin was given in 83 cases, with 78 recoveries and 5 deaths, the death rate being 6 per cent. The death incidence was higher than would have been the case had the antivenin been administered sooner. In the remaining 67 cases in which antivenin was not injected, 23 died, the death rate being 34.3 per cent. In the Northeastern States it has been estimated that the mortality rates are from 10 to 18 per cent of those bitten, the increase being largely due to the Copperhead. In the Southeastern States, Georgia, Florida, and Alabama, the average mortality rates are from 18 to 25 per cent. In Texas, New Mexico, and Arizona the death rate is somewhat higher, no doubt because of the presence of the Western Diamondback Rattler (Crotalus atrox), and ranges from 25 to 35 per cent of those bitten.

Estimates ranging from 100 to 1,500 cases in the United States each year of persons bitten by venomous snakes show the present uncertainty that exists in regard to the prevalence of accidents of this sort. In the majority of the reported cases the victim was bitten on the foot or leg, indicating that a high degree of protection can be obtained by wearing high-topped shoes or heavy leggings. Quail hunters in the swamps and prairies of the South will find that the best protection is afforded by a pair of waist-high rubber wading boots with special inserted canvas shank. In most cases a pair of leather puttees worn over leather shoes will give the necessary protection against snake bites. Indications are at present that Rattlesnakes are increasing in numbers in agricultural districts because of the abundance of rodent food.

The tendency of Rattlesnakes to rattle whenever disturbed and to continue the rattling as long as the disturbing influence is present also explains why victims are not more numerous. The Timber Rattler has been known to keep up its rattle for half an hour with a few intermittent momentary pauses. The fact

that the Water Mocasin lives in unfrequented swamps, and that the Harlequin Snake is of burrowing habits and has a mouth of small size, accounts for the infrequency of bites of these species.

In fatal cases, the time intervening between the bite and death varies in different species. Cases terminating fatally within a few minutes do occur, though fortunately are very rare. There is a record (Roberts) that a boy seven years of age was bitten by a Rattlesnake on the cheek below the eye and putched forward dead before an eye witness could reach him. A little girl three years old was bitten on the forehead by a large Rattlesnake and died within 10 minutes (Blackwood). An analysis of 50 fatal cases resulting from the bites of American venomous snakes showed that 8 persons died in less than one hour, 13 between one and six hours, 18 in from one to twenty-four hours, 4 died on the second day, 4 died between the third and seventh days, 1 at end of nine days, 1 at end of seventeen days, and 1 lived over a month. The duration of illness following snake bite is subject to the widest variation, though in the majority of cases recovery from the constitutional disturbances is complete in two or three days, and in many cases in a few hours. Cases in which illness is prolonged are septic in character and are rarely, if ever, due to the primary action of the venom. The most important complications of snake bite are produced by the absorption of putrefactive substances (sepsis) and by acute alcoholism, resulting from mistaken treatment.

The bites of Pigmy Rattlers and Massasaugas (Sistrurus) are practically never fatal to adults, except possibly through septic complications. These rattlers are our least poisonous snakes, for of 20 cases on record none ended fatally. Of 408 persons bitten by Rattlesnakes (Crotalus), 48 died; on the other hand, of 8 persons bitten by the Harlequin Snake (Micrurus), 6 died. Of 97 cases of bites by the Copperhead (Agkistrodon mokasen) 5 ended fatally, while 9 persons out of 53 bitten by the Cotton-mouth Water Mocasin (Agkistrodon piscivorus) died. When death results from the bite of the Harlequin Snake (Micrurus), it is usually between 18 and 24 hours after the bite. Symptoms of drowsiness and general depression appear within an hour or so, but if the victim survives three or four days, the danger of death passes away.

It is known that bites on the head and trunk are more dangerous than elsewhere, and that the mortality rate for bites on the upper extremities is practically double that for the lower. From 60 to 90 per cent of the total number of cases result from bites on feet or legs. The mortality in children under 10 years of age bitten by our venomous snakes is at least double that of adults.

The number of deaths each year resulting from the bites of our venomous snakes, however, indicates that these snakes are not so dangerous a pest as has often been assumed. This does not mean that one should needlessly take chances of being bitten by a Rattlesnake, for the bite, when not fatal, is followed by exceedingly painful symptoms and often impairment of the part bitten. Young Rattlesnakes only five or six inches long are capable of injecting venom in quantities sufficient to require treatment.

SNAKES COMMITTING SUICIDE

It has been stated that Rattlesnakes are susceptible to their own poison and that death has ensued from the effects of their self-inflicted wounds. There is a possibility, however, that the fang in such cases may have punctured the spinal nerve or some vital organ, and that death, therefore, is not invariably due to the poison. Snakes are not likely to bite themselves except when severely injured or when infuriated and unable to wreak vengeance on the tormentor. C. Phisalix has made experiments on the natural immunity of snakes from their own poison.

TREATMENT FOR BITES OF NORTH AMERICAN POISONOUS SNAKES

There can be no doubt that the chief precaution to take in case of snake bites is to prevent systemic absorption of a fatal dose of venom from the quantity contained in the tissues immediately surrounding the wound. To accomplish this, action must be prompt. Local treatment is of greatest importance, and in addition the patient should be kept warm and as quiet as possible. Mechanical means also may be employed, such as bandaging, abdominal compression, and posture to keep up blood pressure and circulation in the vital centers.

Nowadays administration of antivenin is considered of the greatest importance. As a matter of interest it may be stated that in former years manufacturers of serums and allied preparations regarded the use of antivenins as an impracticable method of treatment in the United States. The Rockefeller Institute for Medical Research carried on experiments with antivenins and prepared small quantities of serum for use in emergencies. It was generally held that an intravenous injection of from 10 to 20 times as much antivenin as the quantity of venom injected by the snake was required to counteract or neutralize the poisonous effects of the bite of a venomous snake. The poisonous snakes of the United States were grouped roughly into three categories according to the type of venom they possessed, and it was believed that three distinct antivenins would be required to provide treatment for cases occurring within the boundaries of the United States.

Recent research has shown that a polyvalent serum could be produced that would be effective for all types of crotaline snakes, or pit-vipers, in the United States, but that persons bitten by coral snakes would have to resort to some other method of treatment. The United States Public Health Service advises that the firm of H. K. Mulford Co., Broad & Wallace Streets, Philadelphia, Pa., recently has been licensed for the production and sale of antivenin, marketed under the name "Antivenin (Nearctic Crotalidae)". So far as known, this is the only concern whose agencies in the United States are marketing a serum effective against the bites of poisonous snakes. The serum for the North American Pit-Vipers (rattlesnakes, copperheads, and water moccasins) is a concentrated antivenin supplied in doses of 10 cc. put up in sterile syringes. The package includes a glass-inclosed sterile hypodermic needle and other accessories. Complete directions are given for assembling syringe and for making the injection, so that self treatment may be given in an emergency if no medical assistance can be obtained. This 'Antivenin' is a purified and concentrated serum globulin obtained

from horses that have been highly immunized against bites of North American pit-vipers. The horses are inoculated by small injections of snake venom, which are gradually increased in strength until they are able to withstand the injection of pure venom in quantities that under ordinary conditions would prove fatal. Antitoxins that neutralize the effects of the venom are produced in the blood of the inoculated horse. The blood of the immunized horse is extracted by humane methods and this is put through a process that separates the serous or colorless portion from the remainder. In this concentrated serum, the serum proteins have been eliminated as they are unnecessary, and this allows the injection of a full dose in a small quantity of liquid. An unconcentrated serum is prepared by the same firm for veterinary use, but the above-mentioned product can be employed for animals also.

The most modern methods of treatment of the bites of Nearctic poisonous snakes are summarized by R. H. Hutchins, as follows in the Bulletin of the Antivenin Institute of America, Vol. 3, No. 2, pp.56-57, July, 1927:

"FOR THE VICTIM

"What to do when bitten

"1. Apply a ligature or tourniquet a few inches above the bite. For this purpose use a rubber garter, a piece of small rubber tubing, a handkerchief, cord, or even a shoe-string. Do not bind the limb too tightly, but just tightly enough to retard circulation returning through the veins toward the heart. The sole object of the tourniquet is to delay absorption of the poison into the general circulation, but if it is applied too tightly or kept on too long, gangrene is likely to set in, with resulting destruction of the flesh in the affected area. It is important, therefore, to release the tourniquet every 10 or 15 minutes for about a minute at a time.

"2. If you have Antivenin with you, read carefully the directions on how to prepare the syringe and how to make the injection. Remember that venoms of North American snakes are usually slow in acting. Do not allow fear or agitation to make you overlook important points.

"3. When the syringe has been made ready, proceed at once to inject the entire contents of the syringe under the skin.

"4. The tourniquet should then be released.

"5. If the bite has been inflicted by a large snake, particularly by the Texas Rattler or the Florida Rattler, and if the symptoms are severe and develop rapidly, the Antivenin treatment should be supplemented by incision and suction.

"Other first-aid measures

"6. If Antivenin is not at hand, there are only two other first-aid measures that have proved of value. These are incision and suction, both of which have been used in Texas in cases of bites inflicted by the Western Diamond-back Rattlesnake. Make a cross-cut incision at each fang mark. For this purpose use a sharp clean knife or razor blade and make the cut all the way through the skin, that is, about 1/4 of an inch deep and 1/2 inch long. This allows some of the poisonous fluids to escape.

"The removal of toxic fluids may be increased by applying strong suction over these incisions. The suction may be done mechanically if some apparatus, such as a breast pump, is at hand. Suction should be continued for 20 minutes out of each hour over a period of fifteen hours.

"7. In any case obtain the best medical attention as soon as possible.

"Don'ts

"Don't run or get overheated. Don't take any alcoholic stimulants. Circulation, increased by exercise or by alcohol, serves to distribute the poison much more rapidly through the body. Don't injure the tissues by injecting potassium permanganate, which is now known to be of no value as an antidote. Do not depend upon snake-bite "cures" or home remedies commonly used. They are of no value. Do not cauterize the site of the bite with strong acids or the like.

"FOR THE PHYSICIAN

"Special directions

"If the victim has not received an injection of Antivenin, it is important to inject the contents of one syringe as soon as possible. At the same time, release the tourniquet, if one has been applied.

"Repeat the injections every one or two hours unless and until symptoms are markedly diminished. In order to hasten the absorption of the serum, intramuscular injections are advised, and, in severe cases and those seen late, intravenous injection is recommended. In small children, when intravenous injection is difficult, the Antivenin may be given intraperitoneally. In shocked cases, physiological salt solution intravenously and blood transfusion are supplementary measures of life-saving value. For weak pulse and threatened heart failure give caffeine or strychnine.

"If incisions have been made at the site of the bite, the wounds should be irrigated with a 1 or 2 per cent salt solution (not normal saline). The application of strong suction may be continued over these incisions, if the symptoms and condition of the patient indicate the necessity of pushing the treatment. Otherwise, apply a hot application of 1:10,000 mercury bichloride or a strong magnesium sulphate solution.

"Extra precautions

"It sometimes happens that after the first shock and reaction has passed, the patients will show marked improvement. Some fatalities from snake-bite are plainly caused by an undue sense of security following the observation that most patients do well for the first 15 hours. Even though the general symptoms may be mild, it is important to keep the patient under close observation for at least 24 hours, and active treatment should be continued as long as the swelling is progressing. Repeat the injections of Antivenin every 1 or 2 hours if the swelling is increasing. The danger is always in under-treatment rather than in over-treatment.

"In treatment of snake-bite in children it is important to double the initial adult dosage. The reason for this is that a mathematical relation exists between the weight of the body and the amount of venom which it can normally neutralize and dispose of without serious injury, although the amount injected by the snake is approximately the same. The smaller and lighter the body of the victim, the less venom it can withstand, and the greater the excess of venom over the normal body resistance. Therefore, if the victim be a young child, there is much more venom requiring neutralization by the serum."

RATTLES

According to popular superstition a Rattlesnake acquires a new ring on the rattle each year, and hence the number of rings composing the rattle was supposed to indicate the age of the reptile. This notion is wholly incorrect, for the Rattlesnake adds from two to four rings each year, usually three. Under normal conditions one ring is added each time the snake sheds its skin. The young Rattler is provided with a single button at birth, and within a few days it sheds its skin and commences feeding; in about two months it sheds its skin for the second time and then the first ring of the rattle is uncovered or added. This has been growing under the old skin, and its presence was apparent in the swollen appearance of the tail at the base of the original button. The last seven or eight vertebrae fuse together shortly after birth and form a composite bone known as the "shaker," and it is around this bone that each cap or ring of the rattle forms.

All of our snakes have the habit of shedding their skin one or more times during the year. The shed skin usually comes off entire, so that from head to tail it forms but a single piece of a very thin transparent material and is generally turned inside out. That part of the skin that covers the cap on the tail can not be shed on account of its peculiar shape. At the time the skin is shed, however, it is loosened and dislodged from its place and moves backward to become an additional ring on the rattle. Thus the rattle of the Rattlesnake is simply a series of shed caps or rings, held together mechanically and loosely because of their shape. The rattle seldom numbers more than ten rings because the vibration at the tip is so great that the terminal rings are soon worn down or broken off.

It has often been asserted that nature equipped the Rattlesnake with this rattle to warn enemies away from its death-dealing fangs. A more reasonable explanation seems to be that the rattle is used as a call during the breeding season, and several naturalists have borne witness to this interpretation. Inasmuch as the range of the buffalo coincided in a general way with the distribution of the Rattlesnake, the rattling of the tail was at least of mutual advantage to both, even though the actual evolution of the rattle was in no way associated with the need of such an organ. The wide-ranging herds of grazing buffalo certainly accounted for a large number of snakes in the course of a season, and any creature that happened to be in the path of a herd would have a better opportunity to escape from being trodden down if it possessed some warning device. The idea that the Rattlesnake can not rattle when its rattles are wet from swimming or being in wet grass or rainstorms, is incorrect.

YOUNG

Early in fall the female Rattlesnake brings forth from six to nine young of about five inches in length, the eggs having been retained in her body until hatched. The young display all the traits of the adults, and will try to rattle and bite as soon as they are born.

The Copperhead and the Water Moccasin are known to give birth to young during the month of July, and a little averages from seven to nine.

Unlike the pit-vipers, the Harlequin Snake is oviparous and deposits its eggs late in May or early in June in decaying bark or damp soil. As many as seven eggs have been found together.

FOOD HABITS

Examination of all accessible accounts indicates that Rattlesnakes feed on any sort of smaller vertebrates that may come within their reach. The following items have been found upon examination of stomachs: Ground squirrels, chipmunks, pocket gophers, young prairie dogs, kangaroo rats, deer mice, meadow mice, and cottontail rabbits; various small lizards such as Uta, Cnemidophorus, and Gerrhonotus; frogs and toads; and occasionally birds as large as quail.

The food habits of the Copperhead and Cotton-mouth Water Moccasin, judging from published accounts, are essentially like those of the Rattlesnake, except that more aquatic vertebrates are available for the Water Moccasin.

The Harlequin Snake does most of its feeding at night, capturing young snakes and lizards, particularly skinks (Eumeces).

BIBLIOGRAPHY

Amaral, A. do, A general consideration of snake poisoning and observations on neotropical pit-vipers. Contrib. Harvard Institute for Tropical Biology and Medicine, II, 64 p., 16 pls. 1925.

---------- Notes on Nearctic poisonous snakes and treatment of their bites. Bul. Antivenin Institute of America, vol. 1, no.3, p. 61-76, figs. 1-30. 1927.

---------- The anti-snake-bite campaign in Texas and in the sub-tropical United States. Bul. Antivenin Institute of America, vol. 1, no.3, p.77-85. 1927.

---------- Studies on snake venoms. Amounts of venom secreted by nearctic pit-vipers. Bul. Antivenin Institute of America, vol. 1, no. 4, p. 103-104. 1928.

Antivenin Institute of America, Bulletin of the, Glenolden, Pa. Published quarterly at $1.50 a year.

Barbour, T., Rattlesnakes and spitting snakes. Copeia, no. 106, p. 36-38. May 20, 1922.

Cope, E. D., The crocodilians, lizards, and snakes of North America. Rept. U.S. Nat. Mus. for 1898, p.153-1294. 1900.

Ditmars, R. L., The reptile book. A comprehensive, popularized work on the structure and habits of turtles, tortoises, crocodilians, lizards, and snakes, which inhabit the United States and northern Mexico. Doubleday, Page & Co., New York.xxxii+472 p., 8 color pls., and more than 400 photos. 1907.

Feoktistow, A.E., Eine vorlausige Mittheilung über die Wirkung des Schlangengiftes auf den thierischen Organismus. Mem. d.l'Acad. Imp. d.Sci. de St. Petersbourg (7), vol. 36, no.4, 22 p. 1888.

Fitzsimons, F. W., The snakes of South Africa, their venom and the treatment of snake bite. T. M. Miller, Cape Town, p. xvi + 550. 1921.

German, S., On the evolution of the rattlesnake. Proc. Boston Soc. Nat. Hist., vol. 24, p. 170-182, pls. 1-2. 1889.

Jackson, Dudley, and Harrison, W. T. Mechanical treatment of experimental rattlesnake venom poisoning. Journ. Amer. Med. Assoc. 90: 1928 June 16, 1928.

Mitchell, S. W., Researches upon the venom of the rattlesnake with an investigation of the anatomy and physiology of the organs concerned. Smithsonian Contrib. to Knowledge, vol. 12, vii + 139 p. 1860.

Mitchell, S. W., and E. T. Reighert, Researches upon the venoms of poisonous serpents. Smithsonian Contrib. to Knowledge, vol. 26, ix + 186 p., pl. 1886.

Noguchi, H., Snake venoms, an investigation of venomous snakes with special reference to the phenomena of their venoms. Carnegie Inst. Washington. Pub. No. 111, xvii + 315 p.,33 pls. figs. 16. 1909.

Phisalix, M., Anatomie comparée de la tête et de l'appareil venimeux chez les serpents. Ann. Sci. Nat. (zool.), Paris, (9), vol. 18, p. 1-114, figs. 1914.

---------- Recherches sur l'immunité naturelle des Vipères et des Couleuvres, Comptes Rendus Acad. Sci. Paris, tome 137, p.270-272. 1903; and Comptes Rendus Soc. Biol., vol. 55, p. 1082-1085. 1903.

Stejneger,L.,The poisonous snakes of North America. Rept. U. S. Nat. Mus. for 1893, p. 338-487, pls. 1-19, 70 figs. 1895.

Tomes, C. S., On the development and succession of the poison fangs of snakes. Philos. Trans. London, vol. 166, pt. 2, p. 377-385. 1876.

Willson, P., Snake poisoning in the United States; a study based on an analysis of 740 cases. Archives Internal Medicine, Chicago, vol. 1, p. 516-570. 1908.

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POISONOUS SNAKES OF THE UNITED STATES

INTRODUCTION

Snakes are easily confused with one another, and the question as to whether a certain one is poisonous or harmless arises again and again. Poisonous snakes are provided with a specific venomous fluid and an apparatus especially adapted for the introduction of this poison into their victims. As it is usual to regard all snakes as venomous, the burden of proof is upon those believing in their innocence. So many wonderful stories concerning snakes have been current from time to time that the public in turn becomes skeptical about everything concerning snakes or firmly believes in traditional accounts that usually are highly erroneous. Allowance being made for misinterpretation of certain natural habits of reptiles, the grain of truth may be perceived in these traditions in spite of the exaggeration that ordinarily accompanies a good snake story. Nevertheless, poisonous snakes are an actual as well as a mental hazard in these days of hiking, camping, and auto picnicking.

The Elapidae, or harlequin snakes (genus Micrurus) are proteroglyphs and occur from South Carolina and Arizona to South America. They are frequently confused with the nonvenomous scarlet snake (Cemophora coccinea) and scarlet king snake (Lampropeltis elapsoides). The former differs from the harlequin snake (and also from the scarlet king snake, which it resembles very closely) in having the ventral surface yellowish white; the scarlet king snake differs from the harlequin in having the black cross bands less than half the width of the crimson.

The Crotalidae, or "pit vipers," are solenoglyphs and occur throughout Temperate and Tropical America and include a number of venomous species that are familiarly known by the following names: Rattlesnakes (Crotalus), massasauga (Sistrurus), cotton-mouth water moccasin (Ancistrodon piscivorus), and copperhead (Ancistrodon mokasen). No true vipers are found on the American continents. The well-known rattlesnakes, of which there are a number of species, are the most specialized of all the venomous snakes. The rattlesnake race has been extraordinarily adaptable, as its members have come to occupy the most diverse conditions of environment, including extremes of both humidity and aridity.

One of the rattlesnakes is known as the water rattler (Crotalus adamanteus), because it is partial to the neighborhood of water and is said to be a good swimmer; yet others, the pallid rattler (Crotalus mitchellii), for example, live in typical deserts. The prairie rattler (Crotalus confluentus) occurs over the dryish areas of the Great Plains, while a related form, Crotalus horridus, is limited to the timbered areas of the eastern parts of the United States. It is certain that rattlesnakes do not habitually climb trees, because they are poorly adapted to such an accomplishment, yet there is unquestionable proof that they do so occasionally. It requires but little more climbing ability to scale a rough-barked slanting tree than the face of a rocky ledge.

The pigmy rattler and the Massasauga (Sistrurus) are diminutive forms of rattlesnakes (Crotalus), attaining a length of nearly three feet and a thickness of less than one inch; their range is chiefly east of the Rocky Mountains, except for Arizona, and they are characteristically forms of the prairies and their swamps and marshes. The diamond-back rattlers (Crotalus adamanteus and C. atrox) are unquestionably the most excitable and most vicious of all North American pit vipers. The red rattler (Crotalus exsul) is said to be the least offensive. The cotton-mouth water moccasin frequents the lowlands along the southern rivers and the adjoining swamps into which the rivers overflow during high water; in its native haunts the cotton-mouth is irritable and pugnacious, and when surprised throws its head back and opens its mouth, disclosing the white lining. In the Northern States the copperhead is partial to rocky places in the vicinity of timber, marshes, or abandoned stone quarries; in the South it frequents higher and drier ground than around the marshes; unless cornered, this snake usually attempts to escape unseen. Nevertheless, the copperhead is a rather dangerous snake, giving no warning of its presence, and striking in any direction.

Key to the Poisonous Snakes of the United States

Smaller snakes, characterized by brilliant colors; markings consisting of broad alternating rings of crimson and black, separated from each other by narrower yellow rings; black bands as broad as the crimson; a pair of short, erect longitudinally grooved fangs in front of upper jaw; head as wide as neck,
Coral, or harlequin, snakes--ELAPIDAE.

Head with yellow band across center and behind this a black ring; yellow body rings very narrow. In humid places from North Carolina to Florida, and westward through Gulf States to Mexico,
Harlequin snake--Micrurus fulvius.

Head black over greater portion; yellow band on back of head and behind this a red ring; yellow body rings broader. Southern New Mexico, Arizona, California, and northern Mexico in region bounded by Rocky Mountains and Colorado River.....Sonoran coral snake--Micrurus euryxanthus.

Larger snakes, characterized by duller colors; markings not forming regular alternating bands, but consisting of blotches, diamonds, or incomplete bands; a pair of long, hollow, freely movable fangs that fold back against roof of mouth when jaws are closed; deep pit on face between nostril and eye; scales on upperparts keeled; pupils elliptical in shape, vertical in position; head wider than neck.....Pit vipers"--CROTALIDAE.

Tail without rattle, ending in a point; top of head covered with shields,
Agkistrodon.

Color pattern distinct; ground color pale brown (grading into pale green on tail in Texas); blotches, or cross bands, reddish brown. Massachusetts to northern Florida, westward to central Illinois, Kansas, and Texas,
Copperhead, highland moccasin, or chunkhead, poplar leaf, or deaf adder.....Agkistrodon mokasen.

Color pattern obscure; ground color light to dark brown; cross bands darker, often indistinct and bordered with yellow spots; some of ventral scales on tail undivided. Lowlands from southeastern Virginia to Florida and Gulf States northward through Mississippi Valley to southeastern Missouri and southern Illinois, and westward through Texas to the Rio Grande,

Cotton-mouth water moccasin--Agkistrodon piscivorus.

Tail with rattle.....Sistrurus and Crotalus.

A single large scale on top of head between supraocular scales (those over eyes).....Sistrurus.

Size small; ground color grayish; large black blotches on back, smaller series on sides. Southeastern North Carolina to Florida, west through Gulf States to western Texas and Oklahoma, northward through Mississippi basin to Arkansas and southern Missouri.

Ground rattler, or pigmy rattlesnake--Sistrurus miliarius.

Size medium; ground color brownish; large black blotches on back in close formation. Western New York to southern Ontario and southern peninsula of Michigan, southward to southeastern Arizona and northeastern Mexico,

Massasauga--Sistrurus catenatus.

Many small scales on top of head between supraocular scales (those over eyes).....Crotalus.

The genus Crotalus has 13 species in the United States, but the characteristics distinguishing these rattlesnakes are too technical for presentation here. Their scientific and vernacular names and statements of their ranges follow:

Crotalus adamanteus--Diamond-back rattler.
About swamps from southern North Carolina to Florida and Keys, westward to Louisiana and Arkansas.

Crotalus atrox--Western diamond-back rattler.
Dry rocky places as well as agricultural districts from Texas and northern Mexico to Arizona; also Lower California.

Crotalus cerastes--Horned rattlesnake, or sidewinder.
Sands of desert plains in northeastern Lower California, southern California, southern Utah, southwestern Nevada, and Arizona.

Crotalus confluentus--Prairie rattler.
Great Plains from southern Canada to Texas.

Crotalus exsul--Red rattlesnake.
Southwestern California, Mexico, Lower California, and islands in Gulf of California.

Crotalus horridus--Timber rattler.
In woody and hilly districts from Maine to Georgia, westward to the Great Plains.

Crotalus lepidus--Green rattlesnake.
Mountains from border region of western Texas to southern New Mexico, Arizona, and adjacent Mexico.
Crotalus mitchellii--Pallid, or bleached, rattler.
Arizona, Colorado Desert to southern Lower California.
Crotalus molossus--Dog-faced rattler, or black-tailed rattler.
Southwest from western Texas to southern Arizona, also highlands of northern Mexico.
Crotalus oreganus--Pacific rattler, or black rattler.
British Columbia to southern California, western Idaho, Nevada, and Arizona.
Crotalus triseriatus--Spotted rattler.
Mountains of southern Arizona and central plateau of Mexico.
Crotalus tigris--Tiger rattler.
Southern California, southern Nevada, and Arizona.
Crotalus willardi--Rattler.
Santa Rita Mountain region Arizona, and northern Mexico.

POISON APPARATUS OF VENOMOUS SNAKES

The fluid, or venom, is injected into the snake's victim by means of specialized teeth on the maxillary bone of the upper jaw, which differ from normal reptilian teeth by having a groove, or canal, from base to apex. These venom fangs are large and readily observed. The canals of the fangs are fed with fluid from poison glands by means of excretory ducts that connect with the latter. Venom does not flow freely except when the snake is actually striking, for the end of the duct, which is not in contact with the base of the fang, is normally compressed by a sheath, or fold of the mucous membrane. A rattlesnake may open its mouth to fullest extent and may or may not erect the fangs. The snake apparently has perfect control over its fangs, raising or depressing them at will. Introduction of venom is accomplished by the combined action of several muscles, which open the mouth, erect the fangs, and compress the poison glands, thus forcing the venomous fluid through the connecting duct into and through the fangs in the brief space of time in which the snake strikes its victim.

At the end of a stroke, the fangs of a poisonous snake are quickly withdrawn from the flesh for the whole action is the work of an instant. Unless the snake strikes again, the mouth closes as the fangs fold back, mechanical compression constricts the excretory duct, and pressure is relieved from the poison glands by relaxation of the enveloping muscles. A poisonous snake often miscalculates the distance of the object at which it is striking. In case the object is too close, the fangs are not fully erect when the snake strikes and hence do not penetrate. Conversely, if the thing struck at is beyond reach, the whole stroke may be completed without touching the object of attack. In this case it may happen that the venom is projected several feet, which has given rise to repeated accounts of spitting by poisonous snakes.

In human beings the bite of a venomous snake is usually followed by painful symptoms and occasionally by death. Other animals are affected in various ways, as in the case of the hog, which has a degree of immunity from the bite of venomous snakes, because of its thick skin and protecting layer of fat.

Poison Fangs

Though the fangs of our venomous snakes are shed frequently, it can not be said that they are shed periodically. On each side of the upper jaw there is a hollow or grooved poison fang firmly ankylosed to the maxillary bone. This pair of functional fangs is supplemented by several pairs of smaller teeth growing loosely in the flesh and buried in the soft sheath of the gum. When from any cause one of the large fangs is broken off, the reserve fang nearest to it moves over in its place, grows fast to the maxillary bone, and becomes the functional poison fang. In case of accident to either of the fangs in use there is always a reserve fang ready to replace it.

Length of Stroke

The idea that a venomous snake can strike its full length or even a greater distance is another popular but erroneous belief. When a snake strikes from its usual S-shaped position, the anterior half of the body, which is thrown forward, must be free from coil. In striking the snake simply straightens out the S-shaped curves. It does not have to be in this position to strike, for observation has shown that when irritated most of our poisonous snakes can strike for short distances from almost any position. The western diamond-back rattler when excited frequently raises its head and the S-shaped loop 10 to 15 inches above the ground, from which position it strikes sideward and downward. When this rattler is lying coiled with its head resting on its body, it is able to strike almost vertically upward. The greatest length of stroke is about three-fourths the length of the snake.

VENOMS OF POISONOUS SNAKES

Venom is a secretion of a supralabial gland that resembles in its development the parotid (a salivary) gland in mammals, and is composed of from 50 to 70 per cent of proteins; the chief remaining components are water and carbohydrates, with occasional admixtures of abraded epithelial cells, or saprophytic micro-organisms, while salts such as chlorides, phosphates of calcium, magnesium, and ammonium occur in small quantities. The reaction of venom to litmus is usually acid; in some cases neutral. The venoms of the different species of poisonous snakes differ to a greater or lesser degree, though all venoms are multiple in nature, that is, they contain several toxins that act independently of one another. Warm-blooded animals are usually more susceptible to venom than cold-blooded. Dried venom retains its original toxic properties in unaltered strength and quality for an indefinite period. Dr. S. Weir Mitchell found that venom kept dry for 23 years was unaltered in these respects. In a fresh state the venom of a snake is a somewhat viscid fluid of a yellowish color.

The effect of venom on the victim is due to the complicated action of several toxic elements, of which neurotoxins and hemorrhagins (explained below) are the most important. Neurotoxins have a destructive action upon the nervous system and play the most important part in producing the death of a victim of venom poisoning. They are present in relatively large proportions and are the chief death-dealing factors in the venom of the harlequin snake (Micrurus), one of the poisonous snakes of the family Elapidae.

Rattlesnakes (Crotalus and Sistrurus) and moccasins (Agkistrodon) of the family Crotalidae produce neurotoxin in comparatively small quantities. The venom of the cotton-mouth water moccasin contains more neurotoxin than that of the rattlesnake, and consequently its paralytic effect on the respiratory center and motor nerves is stronger. This toxin not only breaks down the nuclei of the ganglion (nerve center) cells but produces granular disintegration of the sheath (myelin) and fragmentation of the conducting portions (axis cylinder) of the nerve fibers. These neurotoxins offer a high resistance to heat and retain their toxic properties after prolonged treatment with alcohol.

The hemorrhagins constitute the chief toxic constituents of rattlesnake venom and have a solvent action on the endothelial cells composing the walls of the blood and lymph vessels, particularly the smallest of them known as capillaries. One of the most alarming symptoms ensuing from the bite of a pit viper is the enormous swelling and extravasation of blood around the wound. The blood escapes from the blood vessels through holes in the walls, for the walls of the vessels are really dissolved away in places. Red blood cells as well as white escape upon dissolution of the walls of the blood vessels.

The venoms of different species of snakes dissolve the red blood cells also in a similar fashion. This cell-dissolving substance that has a peculiarly destructive effect on red blood cells is called hemolysin. In dogs inoculated with venom the hemoglobin contained in the red blood cells readily crystallizes. It has been found in animals dying from suppression of urine after being bitten that the tubules of the kidneys are often completely blocked with hemoglobin crystals. The activities of the white blood cells (leucocytes) also are suspended by the action of the venom. Moreover, it has been found that venom contains elements that are agglutinating as well as dissolving for the white cells and that these are distinct from those that affect the red blood cells.

Biochemical studies have shown that snake venom possesses four distinct classes of ferment-like substances apart from the cell dissolvers (cytolysins), and these are the fibrin ferment, and the proteolytic, diastatic, and lipolytic enzymes. One of the most remarkable features resulting from the bite of either the rattlesnake or the moccasin is the loss or the reduction of capacity of the blood for coagulation; it has been found that venom contains a powerful ferment that attacks the fibrin (the coagulating element) of the blood. The proteolytic enzyme of snake venom results in the softening of the muscles; the diastatic enzyme activates the inactive pancreatic juice, enabling it energetically to attack albuminoids; the fourth enzyme has a feeble lipolytic (fat dissolving) action in the splitting of lecithin and in fatty degeneration in the liver.

The quantity of venom yielded at any one time by our venomous snakes varies, in general, in proportion to the size and age of the snake, the length of the period of fasting or hibernation, and other environmental conditions. The pit vipers never inject the entire contents of their glands at a single thrust, the amount injected varying from 25 to 75 per cent of the total, usually about 50 per cent.

Mitchell published the following observations on the quantity of venom yielded by four rattlesnakes:

Length, 18 inches; weight, 9 1/2 ounces; capacity of gland, 11 drops.
Length, 25 inches; weight 18 ounces; capacity of gland, 19 drops.
Length, 49 1/2 inches; weight, 3 pounds 2 ounces; capacity of gland, 29 drops.
Length, 8 1/2 feet; ejected 1 1/2 drams of venom at single bite.

The actual quantity of venom injected into a victim depends largely on the size of the snake, the length of time during which its supply has been accumulating, the depth to which the fang is thrust into the flesh, as well as on the location of the bite. In the majority of cases, human beings recover without any treatment, for the reason that the quantity of venom injected is not a fatal dose.

Mitchell repeatedly pointed out the danger of secondary bacterial infection in victims surviving the primary effects of snake poisoning, and W. H. Welch, in 1893, discovered that rattlesnake venom causes blood to lose its bactericidal power. Normal blood serum destroys thousands of bacteria, while venomized serum does not possess this power.

Some knowledge of the action of crotaline venoms is of greatest importance to American physicians, since 99 per cent of the cases of snake bite treated in the United States are caused by pit vipers.

MORTALITY RESULTING FROM SNAKE BITE

The average mortality from bites of the American venomous snakes was estimated by Willson in 1908 as little more than 10 per cent, and he considered fatalities as extremely rare. A recent study carried on by the Antivenin Institute of America under the direction of Afranio do Amaral (1927) has shown, however, that the danger from snake bite has been underestimated. It was found that in the course of one year (July, 1926, to June, 1927) in Texas something like 150 cases were reported. Of these antivenin was given in 83 cases, with 78 recoveries and 5 deaths, the death rate being 6 per cent. The death incidence was higher than would have been the case had the antivenin been administered sooner. In the remaining 67 cases in which antivenin was not injected, 23 died, the death rate being 34.3 per cent. In the Northeastern States it has been estimated that the mortality rates are from 10 to 18 per cent of those bitten, the increase being largely due to the copperhead. In Georgia, Florida, and Alabama the average mortality rates are from 18 to 25 per cent. In Texas, New Mexico, and Arizona the death rate is somewhat higher, no doubt because of the presence of the western diamond-back rattler (Crotalus atrox), and ranges from 25 to 35 per cent of those bitten.

Estimates ranging from 100 to 1,500 cases in the United States each year of persons bitten by venomous snakes show the present uncertainty that exists in regard to the prevalence of accidents of this sort. In the majority of the reported cases the victim was bitten on the foot or leg, indicating that a high degree of protection can be obtained by wearing high-topped shoes or heavy leggings. Quail hunters in the swamps and prairies of the South will find that the best protection is afforded by a pair of waist-high rubber wading boots with special inserted canvas shank. In most cases a pair of leather puttees worn over leather shoes will give the necessary protection against snake bites.

The tendency of rattlesnakes to rattle whenever disturbed and to continue the rattling as long as the disturbing influence is present also explains why victims are not more numerous. The timber rattler has been known to keep up its rattle for half an hour with a few intermittent momentary pauses. The fact that the water moccasin lives in unfrequented swamps, and that the harlequin snake is of burrowing habits and has a mouth of small size, accounts for the infrequency of bites of these species.

In fatal cases, the time intervening between the bite and death varies in different species. Cases terminating fatally within a few minutes do occur, though fortunately are very rare. There is a record (Roberts) that a boy 7 years of age was bitten by a rattlesnake on the cheek below the eye and pitched forward dead before an eye witness could reach him. A little girl 3 years old was bitten on the forehead by a large rattlesnake and died within 10 minutes (Blackwood). An analysis of 50 fatal cases resulting from the bites of American venomous snakes showed that 8 persons died in less than one hour, 13 between 1 and 6 hours, 18 in from 1 to 24 hours, 4 died on the second day, 4 died between the third and seventh days, 1 at end of nine days, 1 at end of seventeen days, and 1 lived more than a month. The duration of illness following snake bite is subject to the widest variation, though in the majority of cases recovery from the constitutional disturbances is complete in two or three days, and in many cases in a few hours. Cases in which illness is prolonged are septic in character and are rarely, if ever, due to the primary action of the venom. The most important complications of snake bite are produced by the absorption of putrefactive substances (sepsis) and by acute alcoholism, resulting from mistaken treatment.

The bites of pigmy rattlers and massasaugas (Sistrurus) are practically never fatal to adults, except possibly through septic complications. These rattlers are our least poisonous snakes, for of 20 cases on record none ended fatally. Of 408 persons bitten by rattlesnakes (Crotalus), 48 died; on the other hand, of 8 persons bitten by the harlequin snake (Micrurus), 6 died. Of 97 cases of bites by the copperhead (Agkistrodon mokasen), 5 ended fatally, while 9 persons out of 53 bitten by the cotton-mouth water moccasin (Agkistrodon piscivorus) died. When death results from the bite of the harlequin snake (Micrurus), it is usually between 18 and 24 hours after the bite. Symptoms of drowsiness and general depression appear within an hour or so, but if the victim survives three or four days, the danger of death passes away.

It is known that bites on the head and trunk are more dangerous than elsewhere, and that the mortality rate for bites on the upper extremities is practically double that for the lower. From 60 to 90 per cent of the total number of cases result from bites on feet or legs. The mortality in children under 10 years of age bitten by our venomous snakes is at least double that of adults.

The number of deaths each year resulting from the bites of our venomous snakes, however, indicates that these snakes are not so dangerous a pest as has often been assumed. This does not mean that one should needlessly take chances of being bitten by a rattlesnake, for the bite, when not fatal, is followed by exceedingly painful symptoms and often impairment of the part bitten. Young rattlesnakes only five or six inches long are capable of injecting venom in quantities sufficient to require treatment.

SNAKES COMMITTING SUICIDE

It has been stated that rattlesnakes are susceptible to their own poison, and that death has ensued from the effects of their self-inflicted wounds. There is a possibility, however, that the fang in such cases may have punctured the spinal cord or some vital organ, and that death, therefore, is not invariably due to the poison. Snakes are not likely to bite themselves except when severely injured or when infuriated and unable to wreak vengeance on the tormentor.

TREATMENT FOR BITES OF NORTH AMERICAN POISONOUS SNAKES

The following is a combination of recommendations from publications by Drs. R. H. Hutchison and Dudley Jackson (see bibliography):

There can be no doubt that the chief precaution to take in case of snake bites is to prevent systemic absorption of a fatal dose of venom from the quantity contained in the tissues immediately surrounding the wound. To accomplish this, action must be prompt. Local treatment is of greatest importance, and in addition the patient should be kept as quiet as possible.

Don'ts for the Victim

Don't run or get overheated. Don't take any alcoholic stimulants. Circulation, increased by exercise or by alcohol, serves to distribute the poison much more rapidly through the body. Don't injure the tissues by injecting potassium permanganate, which is now known to be of no value as an antidote. Do not depend upon reputed snake-bite "cures" commonly used. Do not cauterize the site of the bite with burning gunpowder, strong acids, or in any other way.

What to Do First

Apply a ligature or tourniquet a few inches above the bite. For this purpose use a rubber garter, a piece of small rubber tubing, a handkerchief, cord, or even a shoe-string, which can be tightened by inserting a stick and twisting. Do not bind the limb too tightly, but just enough to retard circulation returning through the veins toward the heart. The sole object of the tourniquet is to delay absorption of the poison into the general circulation, but if it is applied too tightly or kept on too long, gangrene is likely to set in, with resulting destruction of the flesh in the affected area. It is important, therefore, to release the tourniquet every 10 or 15 minutes for about a minute at a time.

Other First-aid Measures

Make a cross-cut incision at each fang mark. For this purpose use a sharp clean knife or razor blade and make the cut all the way through the skin, that is, about 1/4 inch deep and 1/2 inch long, preferably connecting the fang marks. Suction should then be applied to the affected spot for at least half an hour, and the more blood and lymph that can be extracted the better. If a special suction bulb having more power than a breast pump and with a smaller mouthpiece can be obtained, it will be found highly efficient.

In the absence of any such device, one may remove enough of the venom by suction with the mouth. It is best to be sure that there is no abrasion in the mouth, for the venom is effective wherever it may enter the blood stream. The principal thing to do is to use suction and remove as much of the venom and as quickly as possible. If the above procedure is followed within one hour after the bite, the chances are that no further treatment will be necessary. It is always best, of course, to seek the care of a competent physician as quickly as possible.

While the cutting advised should go through the skin, care should be taken not to cut too deeply nor to sever blood vessels of any size. If inadvertently this is done, bleeding from veins, recognized by the dark red color and steady flow, may be checked by a tourniquet placed on the far side of the cut from the heart. Bleeding from an artery is bright red and in spurts and may be controlled by placing the tourniquet between the wound and the heart. In either case a knot in the tourniquet or a solid object under it should be placed directly over the severed blood vessel.

If you have antivenin with you, read carefully the directions for preparing the syringe and making the injection. Remember that venoms of North American snakes are usually slow in acting. Do not allow fear or agitation to make you overlook important points. When the syringe has been made ready, proceed at once to inject the entire contents of the syringe under the skin near the bite. The tourniquet should then be released for a minute.

Additional Treatment

Additional treatment, or treatment in cases where the above methods were not used soon after the bite, should consist of following up the advance of the swollen area and making a double row of incisions at the very upper edges of the swollen parts. These should be about 1/8 by 1/8 inch, and a series of them should completely encircle the limb affected.

It is well to remark here that novocain can be used by even a layman without ill effect. Besides enabling the one operating to do the cutting without pain to the patient, it also serves somewhat to check the spread of the venom. It may be injected completely around the limb and is very valuable in any emergency where a considerable amount of pain is unavoidable in rendering first aid.

As the swelling advances the one administering medical aid should follow it up with the incisions, and should apply suction for a period of at least thirty minutes to every series of incisions. In case a pocket is formed - that is, one particular region that becomes more swollen than the others - a nest of incisions should be made over and around the pocket and suction also applied there. In case improvement is not shown by the patient, the incisions should be repeated every four hours and the suction kept up constantly. If necessary, it is well to repeat the entire process of making incisions and applying suction until relief is obtained. The punctures will continue to

leak diluted venom and bloody lymph for several hours. The real danger lies in making an insufficient number of incisions rather than too many. Should there be any doubt as to the number made, one should double the amount rather than be content with the minimum.

It is most highly advised to keep the bowels of the patient open and free, using an irrigation of salt and soda solution if necessary.

Special Directions for the Physician

If the victim has not received an injection of antivenin, it is important to inject the contents of one syringe as soon as possible. At the same time, release the tourniquet, if one has been applied.

Repeat the injections every one or two hours unless and until symptoms are markedly diminished. In order to hasten the absorption of the serum, intramuscular injections are advised, and, in severe cases and those seen late, intravenous injection is recommended. In small children, when intravenous injection is difficult, the antivenin may be given intraperitoneally. In shocked cases, physiological salt solution injected intravenously and blood transfusion are supplementary measures of life-saving value. For weak pulse and threatened heart failure give caffeine or strychnine.

If incisions have been made at the site of the bite, the wounds should be irrigated with a 1 or 2 per cent salt solution (not normal saline). The application of strong suction may be continued over these incisions, if the symptoms and condition of the patient indicate the necessity of pushing the treatment. Otherwise, apply a hot application of 1:10,000 mercury bichloride or a strong magnesium sulphate solution.

Extra Precautions

It sometimes happens that after the first shock and reaction has passed, the patient will show marked improvement. Some fatalities from snake bite are plainly caused by an undue sense of security following the observation that most patients do well for the first 15 hours. Even though the general symptoms may be mild, it is important to keep the patient under close observation for at least 24 hours, and active treatment should be continued as long as the swelling is progressing. Repeat the injections of antivenin every 1 or 2 hours if the swelling is increasing. The danger is always in under-treatment rather than in over-treatment.

In treatment of snake-bite in children it is important to double the initial adult dosage. The reason for this is that a mathematical relation exists between the weight of the body and the amount of venom that it can normally neutralize and dispose of without serious injury, although the amount injected by the snake is approximately the same. The smaller and lighter the body of the victim, the less venom it can withstand, and the greater the excess of venom over the normal body resistance. Therefore, if the victim be a young child, there is much more venom requiring neutralization by the serum.

RATTLES

According to popular superstition a rattlesnake acquires a new ring on the rattle each year, and hence the number of rings composing the rattle is supposed to indicate the age of the reptile. This notion is wholly incorrect, for the rattlesnake adds from two to four rings each year, usually three. Under normal conditions one ring is added each time the snake sheds its skin. The young rattler is provided with a single button at birth, and within a few days it sheds its skin and commences feeding; in about two months it sheds its skin for the second time and then the first ring of the rattle is uncovered or added. This has been growing under the old skin, and its presence was apparent in the swollen appearance of the tail at the base of the original button. The last seven or eight vertebrae fuse together shortly after birth and form a composite bone known as the "shaker," and it is around this bone that each cap or ring of the rattle forms.

All our snakes have the habit of shedding their skin one or more times during the year. The shed skin usually comes off entire, so that from head to tail it forms but a single piece of very thin transparent material, and is generally turned inside out. That part of the skin that covers the cap on the tail can not be shed on account of its peculiar shape. At the time the skin is shed, however, it is loosened and dislodged from its place and moves backward to become an additional ring on the rattle. Thus the rattle of the rattlesnake is simply a series of shed caps or rings, held together mechanically and loosely because of their shape. The rattle seldom numbers more than ten rings because the vibration at the tip is so great that the terminal rings are soon worn down or broken off.

It has often been asserted that nature equipped the rattlesnake with this rattle to warn enemies away from its death-dealing fangs. A more reasonable explanation seems to be that the rattle is used as a call during the breeding season, and several naturalists have borne witness to this interpretation. Inasmuch as the range of the buffalo coincided in a general way with the distribution of the rattlesnake, the rattling of the tail was at least of mutual advantage to both, even though the actual evolution of the rattle was in no way associated with the need of such an organ. The wide-ranging herds of grazing buffalo certainly accounted for a large number of snakes in the course of a season, and any creature that happened to be in the path of a herd would have a better opportunity to escape from being trodden down if it possessed some warning device. The idea that the rattlesnake can not rattle when its rattles are wet from swimming or being in wet grass or rainstorms, is incorrect.

YOUNG

Early in fall the female rattlesnake brings forth from 6 to 9 young about 5 inches long, the eggs having been retained in her body until hatched. The young display all the traits of the adults, and will try to rattle and bite as soon as they are born.

The copperhead and the water moccasin are known to give birth to young during the month of July, the litters averaging from 7 to 9.

Unlike the pit vipers, the harlequin snake is oviparous, and deposits its eggs late in May or early in June in decaying bark or damp soil. As many as 7 eggs have been found together.

FOOD HABITS

Examination of all accessible accounts indicates that rattlesnakes feed on any sort of smaller vertebrates that may come within their reach. The following items have been found upon examination of stomachs: Ground squirrels, chipmunks, pocket gophers, young prairie dogs, kangaroo rats, deer mice, meadow mice, and cottontail rabbits; various small lizards, such as Uta, Cnemidophorus, and Gerrhonotus; frogs and toads; and occasionally birds as large as quail.

The food habits of the copperhead and cotton-mouth water moccasin, judging from published accounts, are essentially like those of the rattlesnake, except that more aquatic vertebrates are available for the water moccasin.

The harlequin snake does most of its feeding at night, capturing young snakes and lizards, particularly skinks (Eumeces).

A BIBLIOGRAPHY OF POISONOUS SNAKES

Amaral, A. do. A general consideration of snake poisoning and observations on neotropical pit vipers. Contrib. Harvard Inst. Tropical Biology and Medicine 2 : 64 p., illus. 1925.

---------- Notes on Nearctic poisonous snakes and treatment of their bites. Antivenin Inst. America Bul. 1 (3) : 61-76, illus. 1927.

---------- The anti-snake-bite campaign in Texas and in the subtropical United States. Antivenin Inst. America Bul. 1 (3) : 77-85. 1927.

---------- Studies on snake venoms, amounts of venom secreted by nearctic pit vipers. Antivenin Inst. America Bul. 1 (4) : 103-104. 1928.

Antivenin Institute of America, Bulletin. Published quarterly, Glenolden, Pa., $1.50 a year.

Barbour, T. Rattlesnakes and spitting snakes. Copeia 106 : 36-38. 1922.

Boulenger, E. G. Reptiles and batrachians. 278 p., illus. E. P. Dutton & Co., New York, N. Y. 1914(?).

Cope, E. D. The crocodilians, lizards, and snakes of North America. U. S. Nat. Mus. Rpt. 1898 : 153-1294. 1900.

Ditmars, R. L. The reptile book. A comprehensive, popularized work on the structure and habits of turtles, tortoises, crocodilians, lizards, and snakes, which inhabit the United States and northern Mexico. xxxii+ 472 p., illus., with color pls. Doubleday, Doran & Co., New York, N. Y. 1907.

---------- Reptiles of the world, tortoises and turtles, crocodilians, lizards, and snakes of the eastern and western hemispheres. 373 p., illus. Macmillan Co., New York, N. Y. 1927.

Ditmars, R. L. Serpents of the Eastern States. The venomous and non-venomous snakes of the North Atlantic and New England States with descriptions of the various species. N. Y. Zool. Soc. Bul. 32 (3) : 83-120, illus. 1929.

---------- The poisonous serpents of the world. A comparative review. N. Y. Zool. Soc. Bul. 33 (3) : 79-132, illus. 1930.

---------- Snakes of the world. 207 p., illus. Macmillan Co., New York, N. Y. 1931.

Feoktistow, A. E. Eine vorlausige Mittheilung über die Wirkung des Schlangengiftes auf den thierischen Organismus. Mem. d. l'Acad. Imp.d.Sci. de St. Petersbourg (7), vol. 36 (4) : 22 p. 1888.

Fitzsimons, F. W. The snakes of South Africa, their venom and the treatment of snake bite. xvi + 550 p. T. M. Miller, Cape Town. 1921.

Garman, S. On the evolution of the rattlesnake. Proc. Boston Soc. Nat. Hist. 24 : 170-182, illus. 1889.

Hutchison, R. H. On the incidence of snake-bite poisoning in the United States and the results of the newer methods of treatment. Antivenin Inst. America Bul. 3 (2) : 43-57. 1929.

Jackson, Dudley; and Harrison, W. T. Mechanical treatment of experimental rattlesnake venom poisoning. Jour. Amer. Med. Assoc. 90 : 1928-1929. 1928.

Mitchell, S. W. Researches upon the venom of the rattlesnake with an investigation of the anatomy and physiology of the organs concerned. Smithsn. Contrib. to Knowledge 12 : vii + 139 p. 1860.

Mitchell, S. W.; and Reighert, E. T. Researches upon the venoms of poisonous serpents. Smithsn. Contrib. to Knowledge 26 : ix + 186 p., illus. 1886.

Noguchi, H. Snake venoms, an investigation of venomous snakes with special reference to the phenomena of their venoms. Carnegie Inst. Washington Pub. 111 : xvii + 315 p., illus. 1909.

Phisalix, M. Anatomie comparée de la tête et de l'appareil venimeux chez les serpents. Ann. Sci. Nat. (zool.), Paris (9), vol. 18, p. 1-114, illus. 1914.

---------- Recherches sur l'immunité naturelle des Vipères et des Couleuvres Compt. Rend. Acad. Sci. (Paris) 137 : 270-272. 1903; and Compt. Rend. Soc. Biol. 55 : 1082-1085. 1903.

Stejneger, L. The poisonous snakes of North America. U. S. Nat. Mus. Rpt. for 1893 : 338-487, illus. 1895.

Tomes, C. S. On the developments and succession of the poison fangs of snakes. Phil. Trans. London 166 (pt. 2) : 377-385. 1876.

Willson, P. Snake poisoning in the United States; a study based on an analysis of 740 cases. Arch. Int. Med. (Chicago) 1 : 516-570. 1908.